MONTANA ENERGY POLICY STUDY

ENVIRONMENTAL QUALITY COUNCIL

STAFF DRAFT REPORT

SEPTEMBER 16, 1974

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RESEARCH SUPPORTED BY FORD FOUNDATION GRANT NUMBER 730-0141

REVIEW DRAFT: NOT FOR PUBLICATION OR CITATION

SENATE JOINT RESOLUTION 24
(March 3, 1973)

A JOINT RESOLUTION OF THE SENATE AND THE HOUSE OF REPRESENTATIVES OF THE STATE OF MONTANA DIRECTING THE ENVIRONMENTAL QUALITY COUNCIL TO UNDERTAKE A STUDY, MAKE RECOMMENDATIONS AND PROPOSE LEGISLATION CONCERNING THE DEVELOPMENT AND IMPLEMENTATION OF A STATE ENERGY POLICY AS IT RELATES TO A DEVELOPING NATIONAL ENERGY POLICY AND REQUESTING THE GOVERNOR TO DIRECT THE COAL TASK FORCE TO WORK WITH AND ADVISE THE ENVIRONMENTAL QUALITY COUNCIL.

WHEREAS, the legislative assembly recognizes a need for a state energy policy to contribute and respond to a federal energy policy, and

WHEREAS, a study of this need should carefully separate nationwide problems from those that are matters for action at the state level, and

WHEREAS, there is a need to consider the full range of possible energy sources, optimal efficiency, conservation of use, and administration and regulation of the energy industry, and

WHEREAS, the environmental quality council has received a private grant to make such a study as is described above, which is to relate to an ongoing national energy policy study financed and conducted by the source of the private grant, and

WHEREAS, section 69-6514 (f), R.C.M. 1947, makes it the duty of the executive director and staff of the environmental quality council to make and furnish such studies, reports thereon and recommendations with respect to matters of policy and legislation as the legislative assembly requests, and

WHEREAS, the governor, acting on the recommendation of the environmental quality council, created on August 2, 1972, an interagency task force on coal development to coordinate comprehensive planning incorporating consideration of the social, economic and environmental well-being of Montana people in present and future generations.

NOW, THEREFORE, BE IT RESOLVED BY THE SENATE AND THE HOUSE OF REPRESENTATIVES OF THE STATE OF MONTANA:

That the environmental quality council is hereby directed to undertake a thorough study, prepare a report, make recommendations and propose legislation concerning the development and implementation of a state energy policy as it relates to a developing national energy policy.

BE IT FURTHER RESOLVED, that the governor is requested to direct the coal task force to work with and advise the environmental quality council in conducting a state energy policy study.

BE IT FURTHER RESOLVED, that the avowed purpose of this resolution is to obtain a comprehensive energy policy, together with recommendations for necessary supply of energy in a manner consonant with the preservation of environmental values and the prudent use of the state's air, land, water and energy resources.

BE IT FURTHER RESOLVED, that copies of this resolution be delivered to the Honorable Thomas L. Judge, Governor of the State of Montana; to the Honorable Mike Mansfield and Lee Metcalf, United States Senators from the State of Montana, the Honorable John Melcher and Richard Shoup, Congressmen from the State of Montana and to the Honorable Rogers Morton, Secretary of Interior of the United States, to the presidential Counsellor for natural resources and to the Montana coal task force.

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I. INTRODUCTION

I

The "energy crisis" of 1973 brought to public attention what had been known for some time by a few specialists -- that we can no longer take for granted the unlimited supply and unrestricted consumption of energy. The nation and the states have come to the realization that there should be more careful energy planning. Continuation of unnecessary, uneconomical, and inefficient uses of energy can no longer be tolerated.

Of particular concern to Montana is the development of western coal resources. Some Montanans fear that Montana will bear all the environmental costs of energy extraction and conversion for the region without receiving commensurate benefits.

The Energy Policy Study examines the issues involved in the question of coal development, the need for environmental protection, and the need for adequate supplies of energy to protect the health and safety, promote the general welfare, to assure continued economic stability.

The main objective of the Energy Policy Study is to encourage careful treatment of the environment within the framework of economic activity. (The greatest reduction of damage could be achieved by a complete shutdown of industrial and commercial activity; obviously this is not a viable alternative. People will probably not be grateful for measures which protect their environment at the expense of their jobs.)

Because energy issues are very controversial, it is difficult to make recommendations which will reflect the views of all interested parties. The Environmental Quality Council's recommendations are fundamentally weighted toward environmental protection. EQC arose from the Montana Environmental Protection Act which declares that

> "it is the continuing policy of the state of Montana, in co-operation with the federal government and local governments, and other concerned public and private organizations, to use all practicable means and measures, including financial and technical assistance, in a manner

calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can coexist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Montanans.

(a) In order to carry out the policy set forth in this act, it is the continuing responsibility of the state of Montana to use all practicable means, consistent with other essential considerations of state policy, to improve and co-ordinate state plans, functions, programs, and resources to the end that the state may --

(1) fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;

(2) assure for all Montanans safe, healthful, productive, and esthetically and culturally pleasing surroundings;

(3) attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences;

(4) preserve important historic, cultural, and natural aspects of our unique heritage, and maintain, wherever possible, an environment which supports diversity, and variety of individual choice;

(5) achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and

(6) enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

(b) The legislative assembly recognizes that each person shall be entitled to a healthful environment and that each person has a responsibility to contribute to the preservation and enhancement of the environment."

This is our perspective and the recommendations ought to be viewed with this in mind.

The Energy Policy Study consists of the following sections:

1. Inventory of the alternative energy sources available to the state with a discussion of alternative methods of extraction or conversion and associated environmental costs.

2. Summary of current consumption by end use sectors and possible conservation measures for those sectors.

3. Discussion of the energy consumption in the next decade in Montana and the United States and factors which contribute to the uncertainty about the energy

outlook.

4. Summary of major state and federal regulatory agency activities.

5. Recommendations based on Montana's energy picture

II. Findings and Recommendations

Standard of Living and Life Style--Findings

1. When considering energy or land-use policy recommendations which might have the effect of changing life styles, it must be remembered that an ever increasing higher standard of living measured by per capita income does not necessarily lead to a higher quality of life. A higher per capita income implies more and more consumption of material and energy which in turn usually means more air, water, and land pollution. This is not to say, however, that a higher standard of living must incur greater environmental costs. With stringent environmental safeguards and improved pollution technology, it may be possible to improve both the standard of living and environmental quality. For example, if the economical conversion of solar energy into electricity is achieved an abundant, relatively clean source of energy would be available with minimum environmental and social cost.
2. Through recycling and use of renewable resources we might be able to have sufficient materials at our disposal without imposing unacceptable depletion of finite resources. We should not continue to increase consumption of materials and energy at an uncontrolled rate, counting on new technology to bail us out. We should not assume that environmental problems associated with production and consumption of materials and energy can not be solved through technological advances. A policy of making maximum use of renewable and recyclable materials and energy sources may mitigate some of the environmental problems associated with consumption and production of materials and energy.

David Freeman in his recent book Energy summarizes the situation well:

"The energy policy issue, then, is fundamental, demanding that we reasses our definition of 'growth', our criterea of individual and collective well-being and even our ideal of the American way of life. Many times in our history we have changed, adjusted and matured, emerging stronger. Now we are entering another time of change, another test of our intelligence and maturity.

My study of energy policy has led me to the most difficult and troublesome conclusions: That the United States economy must undergo fundamental restructuring in order to balance our energy budget."

3. The extent to which technology is developed depends upon how much money is allocated to energy research, and the priority different types of research receives. There isn't agreement as to what those priorities should be, although there is general agreement that much more money should be spent on energy research. Past research has focused somewhat narrowly on the development of coal to solve energy problems in the short and medium run, and nuclear energy to supply energy for the long run. This seems to be a rather risky investment; both of these energy sources are finite and have numberous environmental problems associated with their extraction, conversion and use. We are counting on using energy savings (fossil fuels) rather than using energy income in the form of renewable sources such as solar and wind energy.

Standard of Living and Life Style--Recommendations

The recommendations in this energy policy are not intended to cause life style changes, although it seems inevitable that our life styles will change. Conditions around us are in constant flux; if we are to be a viable society, our lifestyles must reflect adaptation to changes.

As the Montana energy policy is revised and evolves to reflect changes in the international, national, regional, and state energy and environmental situation, there may be policy recommendations which affect lifestyle. The public must be made fully aware of the lifestyle changes proposed, (e.g. limits on material or energy consumption).

Pricing--Findings

The full cost of the economic activity such as energy development and consumption should be accounted for in its price, including the cost of using common property resources.

All previously "external" environmental, social, or economic and/or benefits of the extraction, conversion in processing, transportation and use of energy resources should be reflected in the market price of energy. (Externalities are those benefits or costs to a third party which are not incorporated into the economic producer cost or consumer price.)

Costs of environmental degradation, especially long-term effects, have been largely ignored in the past. To some extent, our use of energy has been subsidized; future citizens will have to pay for the cumulative and long-term effects of energy development and use.

Clearly, it will not be easy to assign dollar and cent figures to such external costs. It is extremely difficult to agree upon such costs. For example, the value one person places upon clean air may be much higher than its value to another person. Therefore, assigning a money value to externalities will have to be somewhat arbitrary. However, an attempt must be made to assign some reasonable value.

There is need for research on the effect of current pricing policies on energy consumption. The extent to which price increases decrease demand (prices demand elasticity) is not altogether clear. Certainly wasteful energy consumption should decrease considerably with rising prices; more necessary energy uses will probably not decrease much (For further discussion of price-demand elasticity, see section on Energy Consumption).

Some price changes are inevitable due to higher exploration, extraction, and production costs because of more expensive materials, labor and environmental controls. The additional price changes resulting from possible rate restructuring or new taxation policies must be brought about in a careful and non-disruptive manner.

Pricing--Recommendations

1. The "cost" of the water used in any type of energy conversion facility must be reflected in the price of that energy source. Water is a limited and valuable resource and should not be consumed as a free commodity.
2. A pollution tax should be implemented to include the cost of pollution in the price of energy.
3. A plan for assuring adequate community and social services for coal development regions should be formulated to cover both long-term permanent growth as well as peak construction "boom" growth. The plan might include prepayment of corporate taxes in the form of a tax credit.

Taxation System--Findings

1. Current fossil fuel tax system is neither simply designed nor consistent among the three important fossil fuels.
2. The Net Proceeds Tax as a revenue source is unnecessarily complex and unpredictable.
3. Under certain circumstances energy resource tax receipts are inadequate in quantity and not available when needed to compensate for environmental and social costs on society caused by energy development.

Taxation System--Recommendations

1. Combine Net Proceeds Tax, Oil Producers License Tax, Strip Coal Mines License Tax, Natural Gas Distributors License Tax, and Oil and Gas Conservation License Tax--all into two taxes: one based on gross value and one taxing BTU content of energy sources.

2. Incorporate into the proposed tax system a flexible procedure for distributing the tax receipts to the local counties and school districts where energy development is taking place.
3. Investigate the feasibility of forecasted corporate property taxes to make the revenue available as needed to defray local costs associated with energy development.

Taxation on BTU Consumption--Findings

A tax on the use of BTUs at the point of consumption might serve to more fully equate the price of energy with the full costs of supplying it.

A reduction of growth of energy demand might be achieved while at the same time increasing state revenues needed to solve energy related problems, by levying a tax based upon BTUs consumed at each point of consumption. This tax would apply to all energy used. An energy tax of this sort would promote energy conservation by raising prices while preserving economic freedom of choice and would raise revenue for energy research.

A recent report from the Center for Advanced Computation at the University of Illinois has estimated the potential impact on consumers of a 20 cents per million BTU tax levied on energy consumption. The total burden including pass-throughs by industry and commerce is approximately $35.00 per person per year at 1963 energy consumption levels and prices. In fairness, low income families might be given a flat per capita state income tax deduction because there exists a "subsistence level" of energy use.

Taxation on BTU Consumption--Recommendations

That the state investigate the feasibility of a tax on the BTU-consumption of energy and its effects on energy consumption by residential, industrial and commercial consumers.

The tax on BTU consumption should not discriminate against one type of fuel use or another. This would be a workable substitute until "full-costing" taxation is accepted and economically workable. The BTU tax would provide revenues to solve social and environmental problems associated with energy production and consumption, research on clean energy sources, conservation in building techniques and industrial processes.

Emissions Tax--Findings

Direct regulation of pollution from energy development would force retention of the environmental costs within the development only if all air and water quality standards are met. Whether these standards are met depends on:

1. Administrative and judicial concensus on a scientific basis of standards.
2. The strength of enforcement provisions in the event of violations of standards.
3. Agency manpower, attitudes and budget to enforce the law.

A basic economic inefficiency in this system is the lack of readily identifiable economic incentives to abate pollution (particularly when pollution results from control inefficiencies or lingers because standards are met.)

Emmissions Tax--Recommendation

A mixed strategy is recommended, one combining direct regulation and a tax on pollution. Critical levels of pollution would be defined, beyond which pollution would be taxed severely. A fines system would be appropriate while administrative and judicial clarifications are made. Taxes might be levied against all forms of pollution, significant or not, to impress that all pollution has some environmental cost (degradation). Pollution caused by inefficiencies or accidents also would be taxed.

The taxing scale should vary with pollution, being severe enough at all levels to encourage realistic cleanup efforts. The tax would be a part of existing pollution regulatory systems.

Life-Cycle Costing--Findings

1. The private sector should consider life-cycle costing in its appraisal and financing processes. (Life-cycle costing looks at the costs of a particular building from the perspective of owning and operating costs over the life of the building or system in addition to looking at initial capital costs involved.)
2. Today there is little incentive on the part of the building industry to consider life-cycle costs as their profits are determined solely by construction costs and selling price. Commercial building owners would be uninterested in life-cycle costs if they merely passed on the utility bills to the renters. Homeowners would not necessarily care about life-cycle costs if they did not plan to own their home any length of time.

Life-Cycle Costing--Recommendation

Built-in constraints could be overcome if life-cycle costing became an integral consideration of banks for new construction loans or a part of the appraisal process for setting market prices on existing buildings.

Land Use--Findings

The patterns of land development in Montana will greatly affect consumption. The continued growth of sprawling and distant cities will require considerable energy for transportation.

Land Use--Recommendation

The long-term efficient use of Montana's energy resources compatible with the maintenance of high environmental quality would obtain by compliance with comprehensive and detailed land-use plan. It may be desirable to set aside areas rich in energy resources for future development, making them available both before and after development for other uses. This might be a way of assuring future energy supplies for Montana.

Coal--Findings

1. The development of Montana coal is significantly changing the environment, economy and social structure of eastern Montana.
2. Coal development may conflict with agriculture on several counts. Mine-mouth coal conversion (to electricity, gas, oil) requires large amounts of water. Coal is found in a dry area where irrigation demands are increasing. It is unclear how available water might be allocated among conflicting uses: agriculture, industry, municipal supplies, recreation and maintenance of fish and wildlife values. Siting of mines, power plants, pipelines, rail spurs and transmission lines all may conflict with present agricultural productivity and future growth.
3. Montana coal has two futures: shipment to market for export and utility consumption elsewhere, or conversion at the mine mouth to electricity and synthetic natural gas. The market for exported coal may expand to the point where costs of long-term production and transportation to market meet the costs of desulfurizing eastern coal. In-state market would remain even if desulfurization proved economic because sulfur-in-coal is not a major consideration in gasification.
4. Prices of western coal probably cannot support the true and complete costs of its mine-mouth development. These costs include foreclosure of significant agricultural expansion, disruption of rural communities, water supplies, schools and governments, and implicit commitment to and tacit approval of a wasteful energy policy.
5. Reclamation of strip-mined land remains doubtful in many areas targeted for mining development. Adequate demonstration of both technique and success are lacking, especially on land with alkaline soils.

Coal--Recommendations

1. Montana should apply existing laws to minimize environmental impacts of energy extraction, prohibit mining in areas where reclamation is not possible using known procedures, or as required by law, and minimize economic dislocation of communities. The Strip Mine Siting and Strip Mining and Reclamation Act should be vigorously administered.
2. The Legislature should debate and thoroughly examine basic coal policy statement that would limit coal production to that destined for export from the state and encourage energy developments only to meet the needs of Montana's citizens.

Natural Gas--Findings

1. Natural gas is the cleanest, most versitile and efficient fossil fuel.
2. Natural gas is a scarce fuel.
3. The price of natural gas has been held artificially low by Federal regulation of the wellhead price, encouraging over-consumption.
4. Current gas rates encourage consumption of natural gas.
5. Montana is dependent upon Canadian natural gas supplies although the state has substantial gas reserves.
6. Some Montana gas is exported.
7. Industries and other large users asking for new natural gas contracts are being turned down by utilities.

Natural Gas--Recommendations

1. The state should encourage the exploration for natural gas, particularly for the development of Montana reserves to be made available to Montana gas consumers. This does not mean that the state should encourage the use of natural gas however.
2. The state should support controlled federal deregulation of wellhead prices both to provide incentive for exploration and production of natural gas and also to allow the price of natural gas to rise to a competitive level with other fossil fuels on a BTU basis. The deregulation of wellhead prices should be coupled with a provision that any additional profits resulting from the deregulation be used for the development of new reserves (as long as the energy expended for secondary and tertiary recovery does not exceed the energy extracted), and gasification research (with particular attention paid to such problems as adverse environmental and social impacts, the conflict for water and land with agriculture). Prices are expected to rise with the controlled

deregulation of gas prices, having a dampening effect upon demand (the amount of conservation depending upon the price elasticities of the various gas-consuming sectors).

3. The Public Service Commission(PSC) should thoroughly analyze gas rate structures with special attention paid to the following:
   a. The necessity to conserve natural gas which is the cleanest and most scarce fossil fuel.
   b. Insuring an adequate supply of natural gas for residential and other high priority users.
   c. Cost of service to users.
   d. The possibility of large industrial gas users converting to a more abundant source of fuel (e.g. coal).
4. Gas utilities should be encouraged to send out gas conservation information sheets with their monthly bills.

Alternative Energy Sources--Findings

1. Of alternative energy systems there is little incentive to purchase or operate due to the relatively high cost.
2. There is enough waste generated by cattle on feedlots within a radius of 20 miles around Billings to produce enough methane to supply 25% of the Bird Plant natural gas requirement in Billings.[1] In addition to production of methane, utilization of the wastes for this purpose would alleviate the severe feedlot waste disposal problem plaguing the feedlots, and the sludge by-product would provide a source of fertilizer (which is in short supply in Montana).
3. Information on solar radiation insolation rates in Montana indicated that solar energy could be used as an auxilliary heating source.

Alternative Energy Sources--Recommendations

1. Tax incentives should be offered to home owners installing auxilliary solar heating systems (This would be especially helpful for homes in rural regions relying upon fuel sources in low supply), wind power systems and other methane generators.

2. The feasibility of a prototype methane converter run on feedlot wastes around Billings should be investigated.

Economic Growth and Industry--Objective

Economic growth should be guided along a path consistant with policies designed to improve the environment. Sectors that impose minimum stress on the environment should be encouraged; those that impose severe stree should be discouraged.

Economic Growth and Industry--Findings

1. Because of cheap abundant energy, energy-intensive industries have located in Montana in the past, sometimes resulting in environmental degradation.

2. Strict, but no unreasonable, pollution controls and higher energy prices would have the effect of altering energy-intensive and heavily polluting industries to Montana, but might make it more attractive to light, clean industries. The extent to which industries would be encouraged or discouraged from locating in Montana would depend upon the pollution and energy policies of the region and nation, if surrounding states or the nation had laxer regulation, energy-intensive industries would be drawn to those states; conversely, if Montana's regulations are less stringent and energy prices are lower than in other states, heavy industry would find Montana attractive (as it has in the past).

3. There is room for improvement of the efficiency of industrial energy use.

Economic Growth and Industry--Recommendations

1. Montana should adopt a policy of encouraging those industries which are low polluters and energy users. This policy would have the twofold effect of encouraging economic growth while minimizing environmental degradation.
2. The state might provide investment tax credits for industries purchasing energy-saving capitol equipment (e.g. heat recovery equipment for industrial furnaces, more efficient machinery, furnace insulation, etc.). In addition, utilities might be encouraged to cooperate with the state and lending institutions to provide low-cost loans to industry for purchasing energy-saving equipment.
3. Montana should also encourage a gradual trend away from the industrial use of scarce materials and increasingly large amounts of energy to consumption of material and fuel in a manner more compatible to environmental quality. This shift would not result in economic disruption if it were done slowly and carefully.

Residential Energy--Findings

1. About a third of Montana's energy is used by the residential and commercial sector; most of the energy is used for space heating and cooling.
2. There are considerable energy-saving potentials in the residential and commercial sectors.
3. Lighting standards can be set at lower levels with no adverse effects.
4. Heat loss could be substantially reduced for buildings.

Residential Energy--Recommendations

1. There are different ways the state might assist building and homeowners to improve the insulation efficiency of new and existing structures. The state could allow state income tax deductions for the partial or full cost of installing energy-saving devices such as electric heat

pumps, attic fans, insulation, double-paned glass, weather stripping, storm doors and windows and solar collecting systems.

The state might ask that utilities investigate the feasibility of supplying low-interest loans to homeowners (for energy-saving devices) which would be prorated and repayable with the monthly utility bill and the possibility of initiating regular furnace maintenance schedules.

2. The state should encourage utilities to investigate the feasibility of installing residential or industrial electric heat sinks which are charged during off-peak hours and release their heat during the day, thereby lowering long-run energy costs by reducing peak demand. Industrial heat sinks might also be used to store waste heat from industrial processes. Perhaps the state could offer tax incentives for the installation of such devices as they are expensive to install.
3. New standards for lighting levels in schools and public buildings should be set.

Transportation and Petroleum--Findings

1. There is great potential for improvement in inter-city freight and passenger transportation systems (especially rail systems).
2. There is very little consideration of energy included in state transportation planning.
3. The transportation sector in Montana currently consumes between 25% and 30% of the total energy used in the state. Recently, the national and state trend has been away from the more energy-efficient modes of transportation. The primary mode of transportation in the state is automobiles which vary widely in efficiency.

Transportation and Petroleum--Recommendations

1. The state should begin to develop an energy-environment oriented transportation policy which includes consideration of energy costs in highway and transportation planning.

2. An effort should be made to increase the efficiency and attractiveness of public transportation for both inter-city and intra-city travel, including the improvement of the Amtrak train service. More people might use these energy-efficient forms of transportation if they were made more attractive and convenient.
3. The feasibility of changing current yearly vehicle tax from a market value base to a base reflecting auto horsepower, weight, or some other measure of auto efficiency, should be investigated as an economic incentive to own and operate more efficient autos. Other incentives might include levying gasoline mileage tax on the initial purchase of new cars. (The less efficient the car, the higher the tax would be.) Gas mileage information should be required to be shown on the price tag of new cars in an attempt to make consumers aware of energy consumption tradeoffs associated with each car considered.
4. The State Motor Pool should continue to replace large inefficient vehicles with smaller more efficient ones. In addition, car pooling and conducting state business by phone rather than by travel should be encouraged.

Geothermal Energy--Findings

Geothermal energy is not without environmental impacts. Among the potential problems are surface subsidence, waste water containing large amounts of carbonates, sulfates, and silicates, emissions of hydrogen sulfide gas, land disturbance from pipelines if the energy is used directly, and the environmental impacts associated with electrical generation and transmission if the geothermal energy is being converted to electricity.

Geothermal Energy--Recommendations

All geothermal developers in Montana should be required to comply with existing environmental legislation and to prepare a plan designed to minimize environmental impacts and to meet environmental regulation (e.g. air and water pollution standards)

Coordination of State, Regional and National Policies--Findings

There is a need to coordinate state, regional and national energy policies. Presently, energy policy decisions are being made on a piecemeal basis with little or no coordination. Current state, regional and national policy efforts are duplicated, inconsistent, and divergent. An agency may encourage an activity which another agency discourages.

Coordination of State, Regional and National Policies--Recommendations

1. State policies for transportation, energy, land use, growth, and environment must be consistant.
2. The state must make an effort to establish a dialogue on state-regional and state-national energy policy conflicts.

Revising the State Energy Policy--Findings

Energy conditions are constantly changing.

Revising the State Energy Policy--Recommendations

An energy policy must be flexible enough to accommodate change. The following is an outline of steps for the revision of current energy policies:

1. Energy information gathering and analysing.
2. Program review of agencies to determine compatibility with current policy.
3. Reassessment of current policy to determine if it is consistent with current energy information developments and agency policies.
4. Tentative update of policy attempting to coordinate energy policy with land use transportation, water and other state policies.
5. Public hearings, surveys, etc. to assess public reaction to current policy and proposed changes.
6. Critique of policy by state agencies.
7. Develop energy policy recommendations for the legislature.

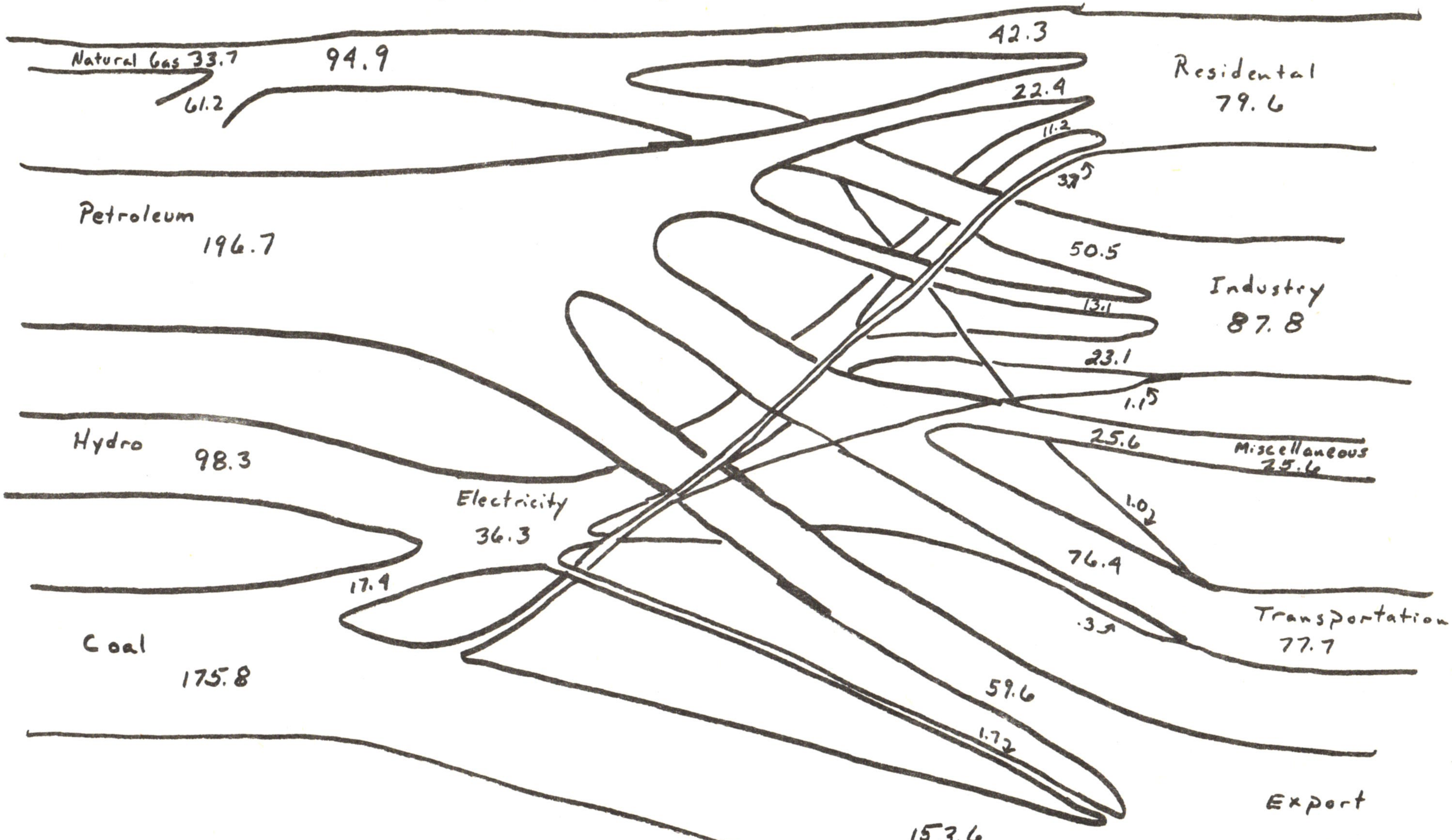
III. TOTAL ENERGY FLOW IN MONTANA

This section briefly outlines energy consumption and production in Montana. Figure 1 shows the state energy flow for 1971.

As Table I shows, coal and petroleum together account for 73.9 per cent of Montana's energy production. Hydroelectric power provides about one-fifth of the state's energy production. Natural gas is only 6.6 per cent of total energy production and is not enough to meet the state's own natural needs. Table I does not include wood and wood wastes burned for fuel in some industries and homes of the state.

Table II presents the total energy consumption for the state. Coal is a much smaller part of energy consumption than of energy production because much coal is exported to Midwest utilities. Large amounts of petroleum and some of the electricity produced in the state also are exported. Canadian natural gas imports make up the gap between demand and supply of this much desired fuel. This energy picture does not include biological energy flow such as the use of solar energy by agriculture to produce fuel.

Figure 1 Montana Energy Flow 1971
(in Trillion BTU)



Sources: 1971 Montana Data Book;
U.S. Bureau of Mines, Division
of Fossil Fuel statistics,
1971 Petroleum Facts (American
Petroleum Institute; Edison
Electric Institue, Gas
Facts, 1971 (American Gas Association)

TABLE I

MONTANA TOTAL GROSS ENERGY PRODUCTION, 1971
(Trillion BTUS)

Energy Source	Energy (Trillion BTU)	Per cent of Total
Coal	175.8	34.9
Petroleum	196.9	39.0
Natural Gas	33.7	6.6
Hydropower	98.3	19.0
	504.7	100.0

Source: U.S. Dept. of Interior, Bureau of Mines, "U.S. Energy Facts," 1971 and Mineral Industry Surveys, 1971.

TABLE II

MONTANA TOTAL ENERGY CONSUMPTION, 1971
(Trillion BTUS)

Energy Source	Energy	Per cent of Total
Coal		
Household and commercial	3.7	
Industrial	1.1	
Electrical Generation	17.4	6.3
	22.2	
Natural Gas		
Household and commercial	42.3	
Industrial	50.5	
Transportation	1.0	
Electrical Generation	1.1	
	94.9	26.7
Petroleum		
Household and Commercial	22.4	
Industrial	13.1	
Transportation	76.4	
Miscellaneous	25.6	
	137.5	38.9
Hydropower		
Electrical Generation	98.3	28.1
	352.9	100.0

Source: U.S. Dept. of Interior, Bureau of Mines Mineral Industry Surveys and U.S. Energy Facts, 1971.

Definitions and Conversion Factors

Kilowatt-hour (Kwh)-The amount of energy used in 1 hour by a load 1,000 watts.

British Thermal Unit (BTU)-The amount of energy required to make one pound of water 1°F, warmer.

Therm-One therm of natural gas contains 10^5 BTU of energy.

Kilowatt (kwe)-10^3 watts electrical energy.

Megawatt (Mwe)-10^6 watts electrical energy.

Million BPD (MBPD)-10^6 barrels per day oil.

Million TPY (MTPY)-10^6 tons per year solids (coal).

Billion CFD (BCFD)-10^9 cubic feet per day.

Acre-foot-one acre-foot of water equals 43,560 cubic feet.

Barrel (bbl)-one barrel equals 42 gallons.

Energy Form	BTU Content
Petroleum	
Crude oil	5.8×10^6/1bbl
Still gas	1500/cubic foot
Liquified petroleum gas	4.01×10^6/1 bbl
Motor and aviation gasoline	5.25×10^6/1 bbl
Jet fuel (naphtha type)	5.36×10^6/1 bbl
Jet fuel (kerosene type)	5.67×10^6/1 bbl
Kerosene	5.67×10^6/1 bbl
Distillate fuel oil	5.83×10^6/1 bbl
Residual fuel oil	6.29×10^6/1 bbl
Asphalt and road oil	6.64×10^6/1 bbl
Petroleum products	5.52×10^6/1 bbl (weight average)
Natural gas	1075/cubic foot
Natural gas liquids	4.4×10^6/1 bbl
Wood	14×10^6/ cord

Energy Form (cont.)	BTU Content
Geothermal	+10,000/kwh
Nuclear	6.7 X 10^7/1 gram Uranium - 235 6.6 X 10^5/1 kilogram reactor fuel (2.5% enriched UO_2)
Electricity	3413/kwh
Hydro	1,000 acre feet X 100 foot drop = 2.35 kwh (at 100% efficiency) 1 acre-foot of water X 100 foot drop = 103.0 kwh (at 100% efficiency)

IV. ECONOMIC IMPACT OF ENERGY DEVELOPMENT

This study does not present independent quantitative analyses of the economic impacts of energy development. There are university and government research efforts underway on the economic impact of coal development in eastern Montana, some results of which are incorporated in the Department of Natural Resources environmental statements on Colstrip Units No. 3 and No. 4.

Because the economic data is being developed elsewhere, this study presents categories that should be included in any economic analysis of Montana energy development. The accuracy of any such analysis will depend on the validity of assumptions concerning:

1. The magnitude and type of development, which in turn depends upon current, and forecasted future market prices, corporate profitability, the availability of capital, competition from product substitutes, water availability.
2. Federal, state, and local governmental attitudes toward development; tax policy, leasing policy, siting and reclamation requirements.
3. The speed of development, which depends primarily upon product prices, governmental policy, and equipment availability.

One qualitative element which should be incorporated in any thorough economic analysis is a consideration of the effects of the economic impacts as they are distributed among the people. For example:

1. What proportion of jobs generated will go to local residents?
2. Will the existing small retail establishments be able to afford paying wages commensurate with those offered by mining or construction companies?
3. Who will pay the short-term costs of supplying needed services (educational, police, waste disposal) to the potential rapid influx of new residents?
4. Will water supplies be decreased or contaminated as a result of strip mining or coal conversion activities?
5. Will the local rancher have difficulty finding seasonal ranch help?
6. Who will be adversely affected by the rise in the local cost-of-living and the increase in short-term school district levies?

An additional component of any economic analysis of Montana energy development should be a projection of the long-term shift in local flows of economic goods and services. Moreover, an attempt must be made to estimate the impact of energy development on the long-term health of the local economic system.

If significant industrialization accompanies resource exploitation, and there is currently the potential for this in several areas in eastern Montana, there will be a shift in the local flow of economic goods and services away from the agricultural sector to the industrial and allied commercial sectors. The local economy will become less dependent upon those factors affecting agricultural welfare (weather, market prices) and more dependent upon corporate decisions, federal leasing and energy policy, and eastern capital markets. Economic power will shift away from large landholders and local banks to the corporate interests. Without debating the merits of these shifts, they will definitely have a long-term impact on the functioning of the local economy.

Non-renewable use of the land base will also reduce the options available to future generations. Reducing future options by irreversible commitments of land and water systems today will reduce the long-term economic health of the local area which, in the case of agriculture, is closely linked to maintaining the environmental integrity of the land and water.

The charts on the following four pages can be used to show the general relationship between different types of energy development (left-hand column) and eight factors affecting the local economic system.

SUMMARY OF MONTANA
ENERGY DEVELOPMENT IMPACTS

	Description of Activity	Population	Employment	Tax Receipts	Personal Income
I	Coal Exploration and Extraction, Transportation	Increase	Increase: Mining Wholesale & Retail Trade Financial & non-financial services Transportation	Increase: Corp. & Personal Income Coal Taxes Local Property & Equipment	Increase: Wages & Salaries Coal Royalties & Leases Trade & Services Transportation
II	Coal Conversion: Electrical Generation Gasification	Increase	Increase: Wholesale & Retail Trade Financial & non-financial services Transportation Construction	Increase: Corp. & Personal Income Local Property & Equipment	Increase: Wages & Salaries Trade & Services Transportation
III	Electricity Transmission	Increase (Short-Term)	Increase: Construction (Short-Term)	Increase: Corp. & Personal Income (Short-Term) Local Property & Equipment	Increase: Wages & Salaries (Short-Term)
IV	Petroleum & Natural Gas Exploration and Extraction, Transportation	Increase	Increase: Mining Wholesale & Retail Trade Transportation	Increase: Corp. & Personal Income Local Property & Equipment Oil Taxes Gas Taxes	Increase: Wages & Salaries Trade & Services Transportation Oil & Gas Royalties & Leases
V	Petroleum Conversion (Refinery	Increase	Increase: Wholesale & Retail Trade Financial & non-financial services Transportation Construction	Increase: Corp. & Personal Income Local Property & Equipment	Increase: Wages & Salaries Trade & Services Transportation

SUMMARY OF MONTANA
ENERGY DEVELOPMENT IMPACTS

	Description of Activity	Public Expenditure	Agricultural Production	Environmental Resources	Cost-of-Living
I	Coal Exploration and Extraction, Transportation	Increase: Schools Roads & Highways Police & Fire Water & Waste Disposal Recreation & Health Facilities Social & Welfare Services	Decrease	Increased Demand for Water Mining People Increased Demand for Land Mining People Transportation Reduction of Air Quality Increased Energy Demand	Increase: Wages Goods Property Property Taxes
II	Coal Conversion Electrical Generation Gasification	Increase: Schools Roads & Highways Police & Fire Water & Waste Disposal Recreation & Health Facilities Social & Welfare Services	Decrease	Increased Demand for Water People Cooling Purposes Increased Demand for Land People Transportation Reduction of Air Quality Increased Energy Demand	Increase: Wages Goods Property Property Taxes
III	Electricity Transmission	NA	Potential Decrease	Increased Demand for Land Construction (short-term) Right-of-Way	NA
IV	Petroleum & Natural Gas Exploration and Extraction, Transportation	Increase: Roads & Highways Police & Fire Water & Waste Disposal	Potential Decrease	Increased Demand for Land Mining Transportation Right-of-Way Reduction of Air Quality Increased Energy Demand	Potential Increase: Wages
V	Petroleum Conversion (Refinery)	Increase: Schools Roads & Highways Police & Fire Water & Waste Disposal Recreation & Health Facilities Social & Welfare Services	Decrease	Increased Demand for Water People Cooling Purposes Increased Demand for Land People Construction Reduction of Air Quality Increased Energy Demand	Increase: Wages Goods Property Property Taxes

SUMMARY OF MONTANA ENERGY DEVELOPMENT IMPACTS

	Description of Activity	Population	Employment	Tax Receipts	Personal Income
VI	Uranium Mining and Milling, Transportation	Increase	Increase: Mining Wholesale & Retail Trade Financial & non-financial services Transportation Construction	Increase: Corp. & Personal Income Local Property & Equipment	Increase: Wages & Salaries Trade & Services Transportation Uranium Royalties & Leases
VII	Uranium Enrichment	Increase	Increase: Mining Wholesale & Retail Trade Financial & non-financial services Construction	Increase: Corp. & Personal Income Local Property & Equipment Uranium Taxes	Increase: Wages & Salaries Trade & Services Transportation
VIII	Geothermal Electrical Generation	Increase	Increase: Mining Wholesale & Retail Trade Financial & non-financial services Construction	Increase: Corp. & Personal Income Local Property & Equipment	Increase: Wages & Salaries Trade & Services Transportation
IX	Solar (Commercial)	Increase (Short-Term)	Increase: Wholesale & Retail Trade Financial & non-financial services Transportation Construction (Short Term)	Increase: Corp. & Personal Income (Short-Term) Local Property & Equipment	Increase: Wages & Salaries Trade & Services Transportation (Short-Term)
X	Wind	Increase (Short-Term)	Increase: Construction (Short-Term)	Increase: Local Property & Equipment	Increase: Wages & Salaries (Short Term)

SUMMARY OF MONTANA ENERGY DEVELOPMENT IMPACTS

	Description of Activity	Public Expenditures	Agricultural Production	Environmental Resources	Cost-of-Living
VI	Uranium Mining and Milling, Transportation	Increase: Schools Roads & Highways Police & Fire Water & Waste Disposal Recreation & Health Facilities Social & Welfare Services	Decrease	Increased Demand for Water Mining People Increased Demand for Land Mining People Transportation Construction Reduction of Air Quality Increased Energy Demand	Potential Increase: Wages
VII	Uranium Enrichment	Increase: Schools Roads & Highways Police & Fire Water & Waste Disposal Recreation & Health Facilities Social & Welfare Services	Decrease	Increased Demand for Water People Cooling Purposes Increased Demand for Land People Construction Reduction of Air Quality Increased Energy Demand	Increase: Wages Goods Property Property Taxes
VIII	Geothermal Electrical Generation	Increase: Schools Roads & Highways Police & Fire Water & Waste Disposal Recreation & Health Facilities Social & Welfare Services	Potential Decrease	Increased Demand for Water Mining People Cooling Purposes Increased Demand for Land Mining People Transportation Construction Reduction of Air Quality Increased Energy Demand	Potential Increase: Wages Goods Property Property Taxes
IX	Solar (Commercial)	Increase: Schools Roads & Highways Police & Fire Water & Waste Disposal Recreation & Health Facilities Social & Welfare Services	Potential Decrease	Increased Demand for Land People Transportation Construction	NA
X	Wind	NA	NA	NA	NA

V. SUMMARY OF ENVIRONMENTAL IMPACT OF ENERGY ALTERNATIVES

Possible Environmental Impacts of Alternative Energy-Related Activities

	Exploration and Extraction	Transportation	Processing or Conversion	Consumption
Coal	Strip mining 1. land use 2. reclamation 3. ground water disturbance Underground mining 1. acid mine water 2. subsidence 3. health & safety hazards	Railroad 1. land use Slurry pipe 1. land use 2. water consumption disposal	Electricity generation 1. air pollution 2. water consumption 3. land use Gasification or liquification 1. land use 2. water consumption	Direct burning 1. air pollution
Electricity	Coal fired generation 1. air pollution 2. land use 3. water consumption Hydro generation 1. land use 2. loss of "free-flowing" character of river 3. relocation of people Gas or oil generation 1. air pollution (not as gas) 2. land use 3. water consumption Nucleur 1. land use 2. water consumption 3. radiation hazard	Transmission lines 1. land use 2. inductive effects		
Petroleum	Blowouts Spills Fires	Pipelines & storage facilities 1. land use 2. spills	Refinery 1. water pollution	Air pollution

Possible Environmental Impacts of Alternative Energy-Related Activites (continued)

	Exploration and Extraction	Transportation	Processing or Conversion	Consumption
Natural Gas	Blowouts Spills Fires	Pipelines & storage facilities 1. land use 2. spills		
Uranium	Health & safety of miners	Radiation hazard	Electrical generation 1. radiation hazard 2. water consumption 3. land use	
Solidwaste			Direct burning 1. air pollution Pyrolysis 1. disposal of wastes	
Solar		Transmission lines (if converted to electricity) Pipelines (if hot water used directly	Unsightly collectors Possible changes in earth heat balance due to decreased albedo Land use	
Wind			Land use	

VI. ENERGY RESOURCE INVENTORY

Coal Reserves and Physical Characteristics

Montana has the largest demonstrated coal reserve base of any state in the nation (about 25 per cent of national total) with an estimated 107.727 billion tons. Surface mining methods are expected to be able to extract 42.562 billion tons of these reserves. The remaining coal, approximately 65.1 billion tons, could be mined by underground methods. The term, "demonstrated coal reserve," refers to coal resources which can be economically and legally mined. These reserves consist of two types of coal, subbituminous and lignite.* Subbituminous coal has an average heat content of 8,500 BTU per pound. Lignite coal has a lower average heat content: 6,750 BTU per pound. Both coal types have significantly lower heat (BTU) content than eastern coal; 50 more tons of Montana coal must be burned to produce equivalent heat energy. Here is a breakdown of Montana's demonstrated coal resource according to type, potential mining method, and percentage of the nation's total reserves:

MONTANA COAL RESERVE BASE
(as of January, 1974 in millions of tons)

Type of Coal	Mining Method: Surface	Mining Method: Underground
Subbituminous	35,431	63,781
Lignite	7,131	not economically minable
Total	42,562	63,781
Per cent of Total U. S. Reserve	31	21

*The demonstrated coal reserve for subbituminous coal includes seams 60 inches or thicker and less than 1,000 feet deep; for lignite, 60 inches or thicker and no deeper than 120 feet. Whenever coal reserve is mentioned in the coal section it refers to the demonstrated coal reserve unless otherwise noted.

The most important physical characteristic of Montana coal is its relatively low sulfur content. Utilities that produce electricity from coal must meet air quality standards limiting the amount of sulfur dioxide released into the air. Utilities are now using low-sulfur fuel to meet these requirements, although the requirements were relaxed somewhat during the oil embargo of 1973-'74. Of the state's strippable coal reserves, 33,761 billion tons are of this low-sulfur variety.

To determine whether a particular coal deposit is suitable for the low sulfur coal export market to utilities, sulfur content per million BTU must be calculated. Since more Montana coal than eastern coal must be burned to generate a million BTUs of heat, even coal with a relatively low sulfur content may become unacceptable due to the cumulative amount of sulfur released into the air.

A general classification of BTU ratings of Montana coal, related to the maximum amount percentage of sulfur per pound of coal it may have and still meet air quality standards is listed below.

COAL HEAT CLASSIFICATION
(In relation to the maximum amount of sulfur allowable and still meet air quality standards)

Heat Ratings (BTUs per pound)		Per cent sulfur per pound
10,000	equal to but no greater than	1.2
9,000	equal to but no greater than	1.0
8,000	equal to but no greater than	.96
7,000	equal to but no greater than	.80
6,000	equal to but no greater than	.70
5,000	equal to but no greater than	.60

Approximately 93 per cent of Montana's strippable reserves have acceptable sulfur content from an air pollution control standpoint. The chart below gives the actual tonnage for sulfur content of Montana Coal according to low-sulfur (meeting present air quality standards) coal tonnage compared to total coal reserves with sulfur content identified.

RANKED SULFUR CONTENT OF MONTANA'S STRIPPABLE RESERVES

Sulfur content Per cent per pound of coal	Coal with low sulfur (million tons)	Coal with sulfur content ident.* (million tons)
.40 or less	24,661.22	24,661.22
.41-.5	5,478.52	5,478.52
.51-.60	1,812.33	1,812.33
.61-.70	312.02	312.02
.71-.80	1,379.88	1,379.88
.81-1.0	118	1,442.52
1.1-1.5	0.0	362.98
1.6-2.0	0.0	628.95
TOTAL	33,761.97	36,078.42

*2316.45 million tons of strippable coal has no sulfur content identification.

Coal Prospecting Permits

Even the most recent coal reserve estimates are subject to change. Coal may be added to or subtracted from the reserve figure as economic or legal conditions change and as the coal regions are further explored (prospected) by energy companies. There has been extensive prospecting in 17 counties in Eastern Montana; six of the counties have no demonstrated surface minable coal reserves.

Prospecting activity is registered by the Department of State Lands which has authority over prospecting permits. The Department issued 48 permits for coal in Montana from June, 1973 to June, 1974.

The following chart lists the number of prospecting permits issued by county:

PROSPECTING PERMITS

Counties (with demonstrated strippable reserves)	Number of Permits
Rosebud	5
Powder River	3
Dawson	5
Custer	6
Wibaux	3
Fallon	3
Bighorn	4
Richland	3
McCone	3
Roosevelt	2
Sheridan	1
Counties without demonstrated reserves	**Number of Permits**
Prairie	3
Carter	2
Garfield	2
Hill	1
Blaire	1
Treasure	1

Coal Leasing

There are at least 614,000 acres in Montana on which coal mineral rights have been leased. Some of this leasing is speculative (i.e. not intended for immediate development, but rather for development when the demand for coal increases). The leases have been issued by the following sources:

Coal Leasing in Montana	Acres Leased
Federal Government (Indian)	91,390
(non-Indian)	36,229
State Lands	56,217
Private	430,397
Total Acres Leased	614,233

The Northern Cheyenne Tribe has been partially successful in petitioning the Department of Interior to cancel all existing leases and prospecting permits it had issued for the Northern Cheyenne. The Crow Tribe recently requested similar action. The status of the 91,390 acres of leased Indian lands is, therefore, uncertain.

It should be noted that the private leasing figure is dated and incomplete. Reports from eastern Montana ranching communities and from coal lease brokers indicate that speculative acquisition of private coal rights is proceeding at a rapid rate.

Current Mining Activity

All of surface mining in the state is area strip mining. (Contour mining is not allowed in Montana under the Strip Mine Siting Act.) Area mining is used in flat or slightly rolling areas where the coal seams are relatively flat. The design of the pit is governed by the equipment and desired level of production. Pits are made in a series of long, narrow strips; as the mining continues, the overburden from each strip is cast back into the open pit of the previous strip where coal has been removed and trucked off. A series of gigantic parallel furrows are formed suggestive of a plowed field.

> "Mine boundaries may be determined by coal burn lines (from historical fires), property lines, or areas in which overburden is presently considered too thick to remove economically. Some active operations are tentatively projected to remove up to one hundred fifty feet of overburden for a fifty foot coal seam."

Production

Production of coal in the state has rapidly increased in the last few years. The estimated 1974 production level exceeds the 1972 production level by twice. The graph shows coal production from 1960 to the present.

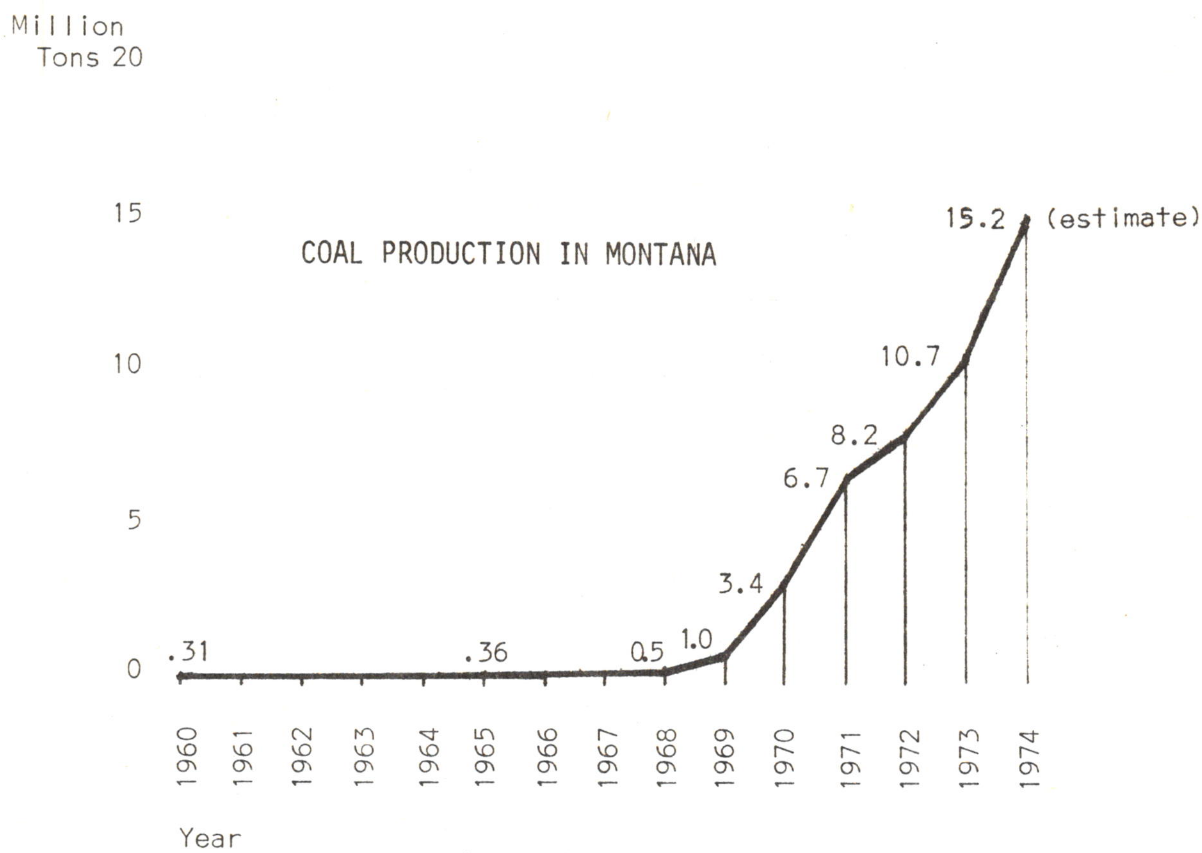
The estimated 1974 production of coal is listed below.

Company	1974 estimated production (million tons)
Peabody Coal Co. (subsidiary of Kennocott Copper)	3.5
Western Energy (subsidiary of Montana Power Company)	2.4
Knife River Coal Co. (subsidiary of Montana-Dakota Utilities)	.3
Decker Mining Co. (jointly owned by Peter Kiewit and Co., and Pacific Power and Light)	6.0
Westmoreland Resources (partnership of Kewanee Oil Co., Morrison-Knudsen Co., Penn Virginia Corp. and Westmoreland Coal Co.)	1.5
TOTAL	15,200,000 million tons

Most of the coal is sold to electric utilities in the midwest. There is one in-state contract from Western Energy for the J. E. Corette steam generating plant in Billings, owned by the Montana Power Company.

Current Coal Transportation

All of the exported coal is transported by unit trains which are used only for the transportation of coal and are assigned to specific destinations. It has been estimated that nationally, one-third to one-half of all coal transported by rail is by unit train. Below is a graph showing the coal mining company contracts in state and the number of railroad cars being used to transport the coal. (Information on other contracts for Montana coal is not available to the public.)


Million
Tons 20
15
10
5
0
COAL PRODUCTION IN MONTANA
15.2 (estimate)
10.7
8.2
6.7
3.4
1.0
0.5
.36
.31
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
Year

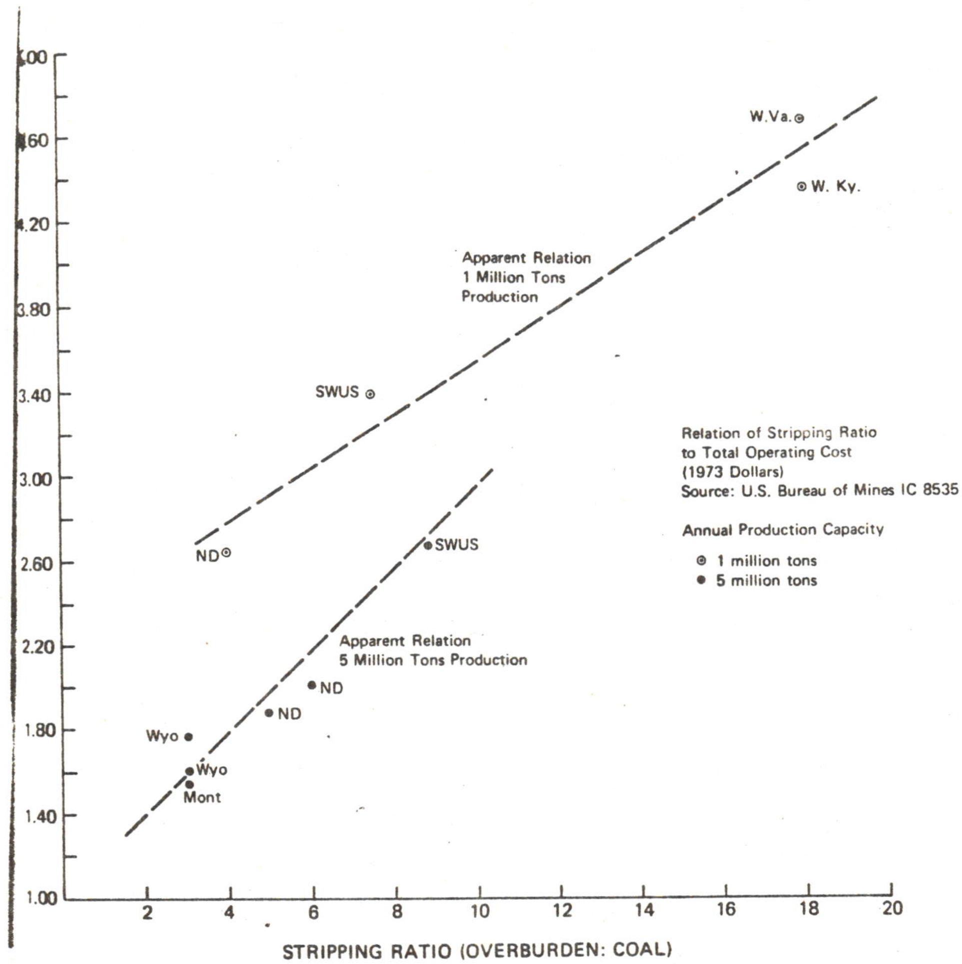
CURRENT USERS OF COAL

Company	Cars per/week 100 Ton/Car	Destination	User
Western Energy	83	Billings, Montana	Corette Steam Generating Plant
	263	St. Paul & Northtown, Minnesota	
	580	Havanna & Hammond, Illinois	Wisconsin Power & Light
	125	Joliet, Indiana	
	8	Other	
Peabody	300	Cohasset, Minn.	Minnesota Power & Light
Decker	500	Havanna, Illinois	Commonwealth - Edison
Westmoreland	832 cars anticipated in 5 years	Minneapolis, Minn. Dubuque, Iowa LaCrosse, Wisconsin Madison, Wisconsin	Northern States Power Interstate Power Co. Dairyland Power Cooperative Wisconsin Power & Light

Cost of the Montana Coal

The cost relationship between various kinds of fossil fuels (coal, oil and natural gas) is measured in the common denominator of heat value, that is, cost per million BTUs. Montana coal is inexpensive compared with other fossil fuels (e.g. oil and natural gas) and coal from other areas. The low operating overhead cost for Montana strip mines is attributable to the thick seams of coal being so close to the surface. This relationship is expressing as the "stripping ratio," the amount of overburden needed to be pushed aside to produce a ton of coal.

> Cost can also be expressed as a function of <u>area disturbed</u> relative to the coal produced. Figure 6-7 shows the lowest operating cost and the least area of disturbance per million tons of coal produced to be in Wyoming and Montana, where the very thick coal seams are covered by relatively thin overburden. In contrast, the highest operating cost and the greatest unit disturbance per million tons are found in states with thinner, more deeply buried coal seams.



There are five states to which Montana coal is shipping for consumption conversion in electric generating plants. In these states Montana coal is competitive on the basis of heat content with oil and natural gas. Below is chart showing the comparative cost of coal, oil and gas measured by cents per million BTU for each state.

COMPARATIVE COST OF FOSSIL FUELS IN SELECTED STATES
(cents per million BTUs)

State	Coal	Oil	Gas	Per Cent of Utilities Using Coal
Montana (Corrette Plant, Billings)	20.8	46.6	24.7	92
Minnesota	41.8	78.8	31.9	69
Illinois	38.0	61.3	51.4	85
Iowa	39.4	85.4	34.6	66
Wisconsin	47.6	78.4	47.8	90
Michigan	44.7	71.0	58.5	84

Notice the relationships between the percentage of consumption of coal by utilities to the natural gas prices. In areas where natural gas costs are lower than coal (Minnesota and Illinois) the percentage drops to the upper 60s. Now, natural gas prices are soon to rise with new federal price deregulation policy changes. As natural gas prices itself out of the market, Montana's coal probably will become more attractive.

A statement made by Lt. Governor Bill Christiansen in the fossil fuel taxation hearings July 19, 1974, further illustrates the cost advantage and hence strong demand for Montana coal:

> There's a producer that has the capacity of about 6.5 million tons; who has 4 million tons subscribed for on a contract. He personally told me that coal consumers (electric utilities) were beating a path to his door to buy the last 2½ million tons of capacity for calendar 1975, and that it looked like he would not even have to go to competitive bidding. And that's a Montana producer.

Future Coal Demand

Future Montana coal production will probably not go below production levels tied to long-term (20-30 year) utility contracts. This market may greatly increase over current levels due to increased demand for low-sulfur coal by these utilities. However, the greatest future demand for the state's strippable coal reserves will be for use in mine-mouth conversion of coal into synthetic natural gas and oil. Policy changes in federal leasing of western coal lands, new reclamation laws, and vigorous promotion of Project Independance would vastly increase the demand for the state's coal reserves. New technology which could desulfurize eastern coal and make eastern reserves competitive with low-cost western deposits may have an effect on the export market (midwestern utilities). The mine-mouth conversion of coal into electricity or synthetic fossil fuels would not reflect this market change. Location of gasification facilities primarily is dependent on availability of large contiguous strippable reserves and low-cost of production of these deposits.

Future Strip-Mined Coal Demand

There are two sets of figures giving an indication of projected strip-mining through 1980. First, there are estimated for 1975 and 1980 coal strip mined production which the Montana Energy Advisory Council (MEAC) compiled and then there are three coal development profiles which NGPRP, an inter-governmental (state and federal) study group compiled for the years 1976, 1980, 1985, and 2000. These projections give an indication of the amount of coal development which would occur given various policy choices.

The Montana Energy Advisory Council has estimated coal production for the years 1975 and 1980 based on known coal sales contracts. These estimates do not include possible new mines opened by 1980 or additional expansions of production at existing mines. New coal conversion facilities located in the state (other than the pending application of Montana Power Company for two new units at Colstrip) are not included. This table shows the estimates for coal production by year, according to use and mining company.

COAL DEVELOPMENT PROJECTION* FOR 1975 and 1980
(millions of tons coal)

Year	Electrical Generation	Coal for Export	Years	% Increase over 1974
1975	0.3 Knife River 0.5 Western Energy 0.4 Western Energy (Colstrip)	3.53 Western Energy 6.0 Decker 4.70 Peabody		
	1.2	18.23	19.43	27
1980	0.3 Knife River 0.5 Corette Plant 3.0 Colstrip I&II 6.0 Colstrip III&IV (if built)	10.32 Western Energy 13.0 Decker Coal 4.0 Peabody		
	9.8	31.2	41.12	170

* Made by Montana Energy Advisory Council (MEAC) based on known sales contracts.

These figures give an indication of what production of coal would be like if the state did not approve any new mines, allow expansion of mining plans for existing mines or accept any more applications for mine-mouth generating facilities.

There are three energy development profiles offered by the Northern Great Plains Resource Program (NGPRP). The NGPRP is an intergovernmental effort involving the five states of the Northern Great Plains Regions (Montana, Wyoming, North Dakota, South Dakota and Nebraska) and three agencies of the federal government. Their study is to project the impacts of coal and energy development in the region. The program made three coal development projections (CDP) based on the following:

CDP I--Base energy coal production and energy conversion facilities to meet region demands and supply existing coal sales contracts.

CDP II--The most probable forecast based on current demand trend.

CDP III--An extensive development forecast showing the possible effects of serious national shortfalls in imported oil and natural gas and delayed nuclear generating capacity.

The table below shows the coal production expected from Montana under each of these forecasts.

NGPRP COAL DEVELOPMENT PROJECTIONS*
(millions of tons per year)

Year	I--Base Development	II--Most Probable	III--Extensive
1975	20	20	20
1980	35	41	64
1985	39	75	153
2000	58	133	393

* Developed fall 1973

When one compares the 1980 MEAC projections and the NGPRP most probable and base projections it is obvious that the "base level" would be surpassed by 1980 production totals.

Transportation of Export Coal

All of Montana's export coal now is transported by unit train. The out-of-state use of Montana's 1980 coal production probably will increase at least 71 per cent over 1975 estimated production. The existing railway system may not be able to handle this load; and equipment, track and operating costs may rise dramatically.

To be sure, much of the coal produced in western mines will move by train, train-barge and train-barge-train systems to major consumers. However, trackbeds need frequent repair and upkeep and existing railroad trackage has a practical saturation point. Beyond this point, new expensive signaling and dispatching systems will need to be added to existing rights of way or new lines will be needed to absorb the increase in coal haulage from these western mines. It does not seem likely that railroads and barge systems can accommodate these possible coal flows from the West. Because of these factors, it is likely that pipeline (slurry pipe) will be a strongly growing competitor to rail systems.

Slurry pipelines transport coal in a pulverized form combined with water to form a slurry. Water for slurry pipelines, if it is exported out of state, is not considered a beneficial use under the Water Use Act, so no state--controlled water may be used for that purpose. Federal water from reservoirs does not have that limitation and can be used for slurry. The chart shows the cost relationship between various forms of transportation for a given amount of Western coal.

Coal For Electricity

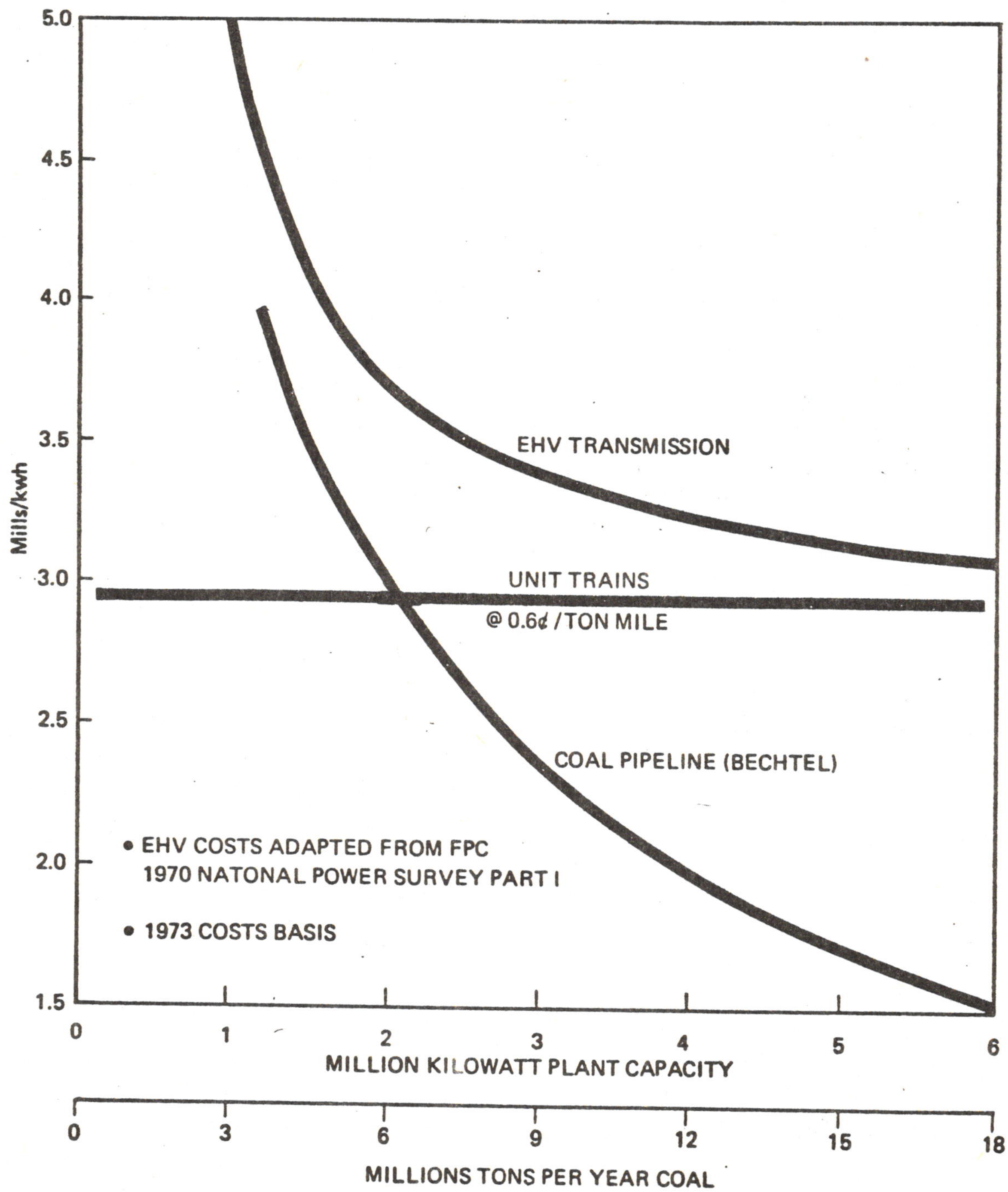
The national demand for electricity is growing at about 7 per cent per year. Approximately 40 per cent of the new national electrical generating capacity for 1975-1977 will be fuel by coal. This percentage already is much higher in the midwest where western coal is competitive with other fuels. To meet air quality standards, low-sulfur coal will have to be used unless technology for desulfurizing eastern coal is used. There are three alternatives which should be considered to meet air quality standards and still burn coal:

1. Eastern underground low-sulfur reserves, which are 30 times larger than western low-sulfur reserves, could be used in these facilities.

2. Sulfur can be washed out of high-sulfur eastern coal before it is burned, but this process reduces the heat value (BTU/pound) and may not be reliable.

3. Stack scrubbers could be used to extract sulfur from emissions before release to the atmosphere (desulfurization technology).

FIGURE 2 COST COMPARISONS OF ALTERNATIVE MODES OF COAL ENERGY TRANSMISSION (for 1,000-mile transport distances)



The three alternatives, unfortunately, currently cost more (in dollars per million BTUs of coal burned) than the choice industry is making now--use of low-sulfur western coal. Market changes could change the picture dramatically, however.

Coal for Synthetic Gas Production

A technology for conversion of western coal into commercial quantities of pipeline quality synthetic gas called the Lurgi process of coal gasification is available now. The El Paso Natural Gas Company is building a Lurgi gasification plant of commercial size. This plant will product a low-BTU gas from coal and concentrate it into a synthetic natural gas of pipeline quality (around 1,000 BTU per 1,000 cubic feet). The process is designed to work will with coal similar to Montana coal. Projected cost for the process including transportation to a city's natural gas distribution lines would be about $1.10 to $1.50 (1972 dollars) per million BTUs. This process would become competitive with natural gas prices which are expected to rise as high as $2.00 per million BTUs. The resources required to operate such a plant are listed next:

COAL GASIFICATION RESOURCE REQUIREMENTS

	Hypothetical Location near Decker Mt. (250 mmcfs)	El Paso Plant (288 mmcfs)
Water	17,000 acre-feet per year	10,385 acre-feet per year
Acreage (for plant)	1,030 acres	1,915 acres
Coal requirements (tons per year)	8 million	9.383 million (8,664 BTU coal)
Reserve requirements	300 million	274 million

Another reason western coal is being considered for conversion into synthetic natural gas is the low cost of these resources. "The supply of coal for conversion or liquids during the 1971-1985 period can be expected to be based largely on use of surface coal deposits in the Rocky Mountain area in view of the much lower mining cost of that coal." (As stated earlier, Montana coal is among the least expensive to extract in the nation.) "This does not mean that only western coals will be used for synthetic feedstocks. Coal from other areas may be used but the quantity would probably be very small as compared to western coal."

Plans already have been announced for five gasification plants and one synthetic fuels and fertilizer plant. An application is pending with the Department of Natural Resources and Conservation for two additional power plants at Colstrip (Colstrip Units No. 3 and No. 4). On the next page is a chart of announced energy conversion facilities, coal to be consumed, and general location. If allowed under the Utility Siting Act of 1973, these plants demand a 62.3 million ton a year increase in Montana strip mine coal production.

The National Petroleum Council developed three synthetic natural gas projections based on different sets of circumstances. Case I was a projection based upon the events that called for a maximum rate of buildup in the synthetic fuels industry to meet demands for oil and gas in the absence of firm natural supplies. This projection is probably equivalent to the type of development necessary to have energy self-suffiency in the nation by 1985. Cases II and III, called for a rapid but practical buildup rate to meet slowly growing shortfalls of conventional oil and gas supplies. This projection would be equivalent to the amount of development needed to meet energy demands with shortages in natural gas and oil, but not necessarily needed for energy self-suffiiciency. Case IV is a projection based upon a minimum rate of buildup which was based on 1972 natural gas and oil prices that have gone up tremendously. Montana's projected role in these scenarios is depicted in the chart below, with the number of 250 mmcf gasification plants which would produce the required pipeline quality gas.

COAL GASIFICATION PLANTS IN 1985

coal type	Case I no. of plants	million tons of coal	Case II/III no. of plants	million tons of coal
subbituminous	6.4	46.08	3.0	21.6
lignite	8.0	72.8	3.6	32.76
Total	14.4	118.88	6.6	54.36

coal type	Case IV no. of plants	million tons of coal
subbituminous	1.0	7.2
	0.0	0.0
Total	1.0	7.2

If the plants which have been announced by corporations were built by 1985, (5--gasification plants) Montana would have approximated Case II/III. If no new mines were built (other than for Case II/III plants) and present mines did not expand production after the 1980 MEAC estimates (based upon known or expected contracts), Montana's total coal production would be 95.48 million tons with 6.8 square miles of land being disturbed annually for mining of this coal.*

The Northern Great Plains Resource Program (NGPRP), has specific coal conversion scenarios for Montana in addition to the coal production projections. Again they use the three classifications of "base," "most probable," and "extensive." The base level of development includes four 1,200 megawatt power-plants for Montana. The "most probable" projection includes four 1,200 megawatt power pants and six 250 mmcfs gasification plants. Three 1,200 megawatt power plants and fifteen 250 mmcfs gasification plants are included in the "extensive" level of development.

SUMMARY OF NGPRP CONVERSION PLANT PROJECTIONS

	Base	Most Probable	Extensive
Powerplants	4	4	3
Gasification	0	6	15

Thus it would seem that "most probable" projections are realities today in terms of coal development for Montana. As supplies of natural gas and petroleum decline, and prices rise, the demand for in-state coal conversion facilities will increase, probably to the NGPRP's "extensive development" projection.

Coal and Environmental Effects

New research on the environmental impact of coal production in Montana is pending for this study. Impacts of coal development will be addressed fully in the final study.

Water and Coal Conversion Development

The need for water related to coal conversion plants is especially demanding compared to limited supplies in the easter Montana coal regions. (For a full discussion of the water demand for the coal conversion industry and its relationship to amounts of water already controlled, see the water section of this report.) In mine-mouth electric generating plants certain features such as dry cooling towers may be used to lessen the amount of consumptive use of water. In the synthetic fuels industry water is a vital input into the process. "The water problem is not trivial. In coal gasification, water is used as a process input, the source of the hydrogen, which when added to the carbon in coal, produces synthetic methane(gas). It is not simply used as a coolant and returned to its source." The development of the coal conversion industry would seriously impair irrigation plans for river systems in the region and would foreclose growth of irrigation in many parts of the state (see water report following this section.) An alternative to Montana coal gasification would be: "It should be noted, however, that given water problems, distance from major markets (which require extensive pipelining) and available economically recoverable reserves, coal gasification plants in the states of Illinois, Indiana and Ohio would appear to be economically superior to those in the Rockies."

Analysis of Coal Projections

When the projections are compared there are similarities which give an indication of the present trend of coal development in Montana. The NGPRC's "most probable" projections of coal development projects are very similar to those of Montana Energy Advisory Council's 1980 estimates. Conversion plant projections by NGPRP are very similar to the level of development which would occur if the plants which have been announced were built.

Plans already have been announced for five gasification plants and one synthetic fuels and fertilizer plant. An application is pending with the Department of Natural Resources and Conservation for two additional power plants at Colstrip (Colstrip Units No. 3 and No. 4). On the next page is a chart of announced energy conversion facilities, coal to be consumed, and general location. If allowed under the Utility Siting Act of 1973, these plants demand a 62.3 million ton a year increase in Montana strip mine coal production.

ANNOUNCED CONVERSION PLANTS IN MONTANA

Facility	Location	Capacity & Coal Consumed	Status
Burlington Northern synthetic fuels plant	Northwest of Circle, McCone County.	Daily production ammonia, methanalmethy fuel and synthetic diesel fuel Coal-13.0 million tons/ year.	State has received applications for water, first part be constructed 2 years--whole project by five (may not need Utility Siting Act approval)
Northern Natural Gas--Cities Service Co. gasification project	Southeast Montana	4 standard synthetic natural gas plants. Coal-approximately 40.0 million tons/year.	Construction could start in 1976-1977, operating 1979-1980.
Colorado Interstate Gas--Westmoreland Coal Company	Southeast Montana.	One standard synthetic natural gas plant, 9.3 million tons/year	Colorado Interstate has an option on 300 million tons of coal and 10,000AF water for project.
Colstrip units No. 3 and No. 4	Colstrip, Rosebud Co.	700 megawats apiece; 1400 total (included in 1980 MEAC estimates)	30 per cent of power for in-state use; application at DNR--recommendation to be made on or before 1/31/75.

THE DEMAND FOR WATER

Energy Conversion and Agriculture

The mine-mouth coal conversion* industry in the state will have a direct impact on future water suppliesin Eastern Montana. The coal conversion industry has yet to open a plant in Eastern Montana, but one plant is being built and others have been announced. Extensive coal conversion, because of its massive demand for water, would prevent significant growth of irrigated agriculture in Montana west of the continental divide. The question is, what level of industrialization would be compatible with future growth of agriculture. Are four power plants too many? Eight? Sixteen? There are limits to the policies which may be enacted to influence future water uses in Eastern Montana. And some decisions already have been made -- the federal government has contracted for delivery of water for coal-related industry. This section of the study identifies tradeoffs which may be made pursuing various levels of agricultural and industrial development.

Federal and State Water Policies and Status

Federal and state agencies can have great effect on water uses in Montana. The federal Bureau of Reclamation can determine for what uses the water can be sold from its dams and projects. Also, with consent of Congress, it can build additional dams, regulate stream flow, limit water availability and make water allocations. Under its "Industrial Water Marketing Program" the Bureau of Reclamation quietly sold 708,000 acre-feet of water and has files of requests from energy corporations for an additional 1.8 million acre-feet of water for use in the northern plains region (Montana, Wyoming, and North Dakota). The Bureau has conducted a number of studies such as the <u>Montana-Wyoming Aqueduct</u>

*Conversion of coal into other forms of energy, i.e. electricity, and synthetic natural gas and oil.

Study, Report on the Resources of Eastern Montana Basins, and the Water Work Group Report for the Northern Great Plains Resource Program (NGPRP), which have, to varying extents, studied potential supplies of water for coal conversion facilities. The State through the Department of Natural Resources (DNR) has jurisdiction under the Water Use Act to allocate water for agricultural, municiple, and industrial uses. The 1974 Legislature directed DNR to suspend action on water appropriation requests in the Yellowstone Basin under the Act for three years. The suspension affects primary requests for industrial diversion and impoundment and directs DNR to adjudicate existing water rights. Meanwhile, state agencies (and other political subdivisions of the state) can make reservations of water for future uses. These two acts give Montana some control of future water use for industrial coal development, but federal water policy not subject to state control may outweigh any state influence.

Federal Policies

In 1967, the Bureau of Reclamation began selling water for energy conversion from three reservoirs, first from Yellowtail Unit (near the Montana-Wyoming border) and later from the Boysen Unit (Wyoming) and Ft. Peck (Montana). These reservoirs were not originally intended to provide water for industrial purposes. A quotation from a December, 1967 Bureau of Reclamation memorandum concerning a soon-to-be executed contract for water from Yellowtail Reservoir gives some reasons for the policy change:

> In view of the vast coal deposits in the area and the interest from commercial firms in obtaining a reliable water supply to develop petrochemical industry from these resources, and the fact that a large part of the conservation space of 614,000 acre-feet for hydrogeneration is excess to irrigation and other project requirements the cost of Yellowtail Dam and Reservoir was reallocated using industrial water as one of the purposes. Studies confirm that a firm industrial water supply slightly in excess of 200,000 acre-feet would be available after allowances for anticipated and planned future irrigational development above and below the reservoir. (our emphasis)

By May, 1971, when the Bureau finished signing contracts, it had sold 393,000 acre-feet more than it had planned to sell when "anticipated and future irrigational development" was still a factor. The total sold from Yellowtail, Boysen and Fort Peck Reservoirs was 708,000 acre-feet of water. In addition, pending requests for industrial water total more than 1.8 million acre-feet. The Bureau of Reclamation has estimated that more than 1.3 million acre-feet of the total was either contracted or requested for use in Montana. (See Appendix A) *

The sales contracts under this program provide that water be put to a beneficial use by the contractor (energy corporation) for <u>industrial use only</u>. Signed water contracts allow delivery of water anytime after the date of execution. Other contract provisions affecting coal conversion development allow substantial changes to be made in water delivery on the 10th year after the contract has been executed, and require air and water pollution controls on conversion facilities using this water. The industrial user must request initial delivery of the water before the 10th year of the contract or it will be terminated. Termination of the contract also follows when water isn't used for three years after intial delivery request. The Bureau may limit the maximum amount of water to be delivered to that amount which is being used on the 10th year of the contract.

The Bureau is now considering a number of strategies to supply water for various levels of industrial development. Under the Northern Great Plains Resource Program (NGPRP), federal interagency study of coal development in the northern plains region, the Bureau examined water availability according to three energy development scenarios. It then examined the actions that would be required to supply water for these levels of development. (The NGPRP energy scenarios and water availability are discussed after State Policies.)

*Appendix A not reproduced for review draft.

State Policies

A number of applications for appropriations have been filed by energy companies for state-controlled water. (This would include all water not now controlled by federal agencies; presently those not related to federal reservoirs or projects.) The total of these applications is 787,450 acre-feet per year, generally for coal conversion facilities. Unlike provisions of federal contracts, these state appropriation requests could be used for irrigational, municipal and domestic uses as well as for energy plants. Because none of the appropriations has received approval, there is no sure way to know how the water would be used. (See Appendix B*for state appropriation requests.)

Approval for these applications must wait for expiration of the three-year water moratorium. Meanwhile, DNR is studying the Yellowstone River Basin to determine existing water rights to water and the amount that must be reserved to protect existing agricultural, recreational and municipal uses. Under the Water Use Act, these reservations can be made by agencies of the state or its political subdivisions. For example, the state Department of Fish and Game has requested a reserve of water in the Yellowstone Basin to preserve its fish, waterfowl and wildlife capabilities. State water policy in the face of impending coal development appears to be "wait and see" until the water moratorium expires or a replacement policy is devised.

Industrial Water Demands

Future water demands have some relation to present NGPRP energy development scenarios, pending state appropriations, and federal Bureau of Reclamation water contracts and requests. The executed federal water contracts show industry's serious interest in coal conversion in the state. So far, corporations have paid $603,000 (50 cents an acre-foot per year; a total of $114,000 a year) to retain the federal water options. It is reasonable to assume that industrial leaders

*Appendix B not reproduced for review draft intend to profit by the use of these waters as far as federal and state energy policies permit.

Three energy development projections are offered by the NGPRP. These three were developed as a basis for a coal development program, but there has been strong official criticism of their validity. The report of the NGPRP's Water Work Group described two kinds of industrial facilities, coal fired power plants and coal-consuming synthetic gas plants. It is assumed that each 1,200 megawatt steam-generating electrical plant would consume 23,000 acre-feet of water a year for cooling purposes. It is also assumed that each gasification plant, able to produce 250 million cubic feet of synthetic natural gas per day, would consume 30,000 acre-feet of water per year. (For comparison, Colstrip Units No. 1 and No. 2 (producing 700 megawatts) are planned to consume 4,000 acre-feet a year)

According to the NGPRP (see Appendix C*), coal development could occur at "base," "most probable," and "extensive" levels.

In Montana, the "base" level would include four in-state 1,200-megawatt power plants, together requiring 92,000 acre-feet of water a year. The "most probable" level of development would include four 1,200 megawatt power plants, and six coal gasification plants, requiring a total of 272,000 acre-feet of water per year. The "extensive" level of development would include three 1,200 megawatt power plants and 15 gasification plants, and would require 519,000 acre-feet of water a year altogether. With the extensive development, there also would be a new population migration, to seven counties in Eastern Montana, of 127,000 people. New municiple water requirements would be 27,500 acre-feet per year. This would up the total water requirement, in this scenario, to 546,000 acre-feet a year.

*Appendix C not reproduced for review draft.

Summary of NGPRP Energy Development Projections

Level of Development	Conversion Facilities	Amount of Water (Acre-feet per year)
Base	4 power plants	92,000
Most Probable	4 power plants 6 gasification plants	272,000
Extensive	3 power plants 15 gasification plants plus new Pop.'s municipal water requirements	519,000 546,000

Although it uses the phrase "extensive development" to categorized the potential consumption of 546,000 acre-feet annually to feed power and gasification plants, the NGPRP report may represent a serious underestimation of industry intentions. Ignoring for a moment the fact that the Bureau of Reclamation has earnest industry requests for 1.3 million acre-feet of water designated for withdrawal and use in Montana, the Bureau has nearly enough sold (228,000-acre feet) to satisfy the "most probable" scenario of the NGPRP--and easily so if the fair assumption is made that that industry has overestimated its needs.

As for the earnest industry requests: if they were granted (here ignoring the environmental and economic impacts of the decision), industry would have available twice as much water as would be required to satisfy the demands of energy conversion plants in the "extensive level of development" scenario of tomorrow. And the applications for federal water, it will be recalled, are only part of our story of industrial thirst: the state has been asked to allow another 787,450-acre feet in withdrawals.

Clearly, NGPRP development projections fall far short of indicating the possible extent of future energy-development water demands and also fail to point out that the "most probable" future could be an assured reality today even with no further action by state and federal governments on industrial water requests.

Summary of Firm Contracts and Requests (Federal)
and Applications for Appropriation (State)
Compared to NGPRP Energy Development Scenario for Montana

Agency	Acre-feet per Year	Requirements to fulfill NGPRP Developments
Bureau of Reclamation (Federal)		Base Development-- (less than ½ of contracted water)
contracts executed	228,000	Most Probable-272,000
request pending	1,087,000	
SUBTOTAL	1,315,000	Extensive-519,000
Department of Natural Resources (State)		Actual Grand Total is slightly more than 4 times extensive development water requirements
request for appropriation	787,450	
GRAND TOTAL	2,102,450	

Agricultural Water Demand

A number of things should be considered when discussing future irrigation requirements in relation to coal development. First, the effect of coal conversion water requirements must be viewed as a basin-wide problem. Water which is committed downstream by appropriations cannot be legally used upstream. Second, any promise of water for coal-related industrial development should be viewed as at least a 40- to 50-year commitment. A mine-mouth electrical generating facility has an estimated life-span of 37 years, for example. Only if the plant were not replaced would the water be available for other uses. Third, energy development's water withdrawals may cause difficulties for any irrigation project because massive withdrawals would reduce surface levels of waterways.

The bulk of agricultural use of surface water in Upper Missouri River Basin is for irrigation. In determining future irrigation water demand, four variables must be considered: potential arability of the land according to soil capability and topography; proximity of water to this land; water requirements for its irrigation, based on crop needs and irrigation efficiencies; and lastly, the market conditions for agricultural products, which determine whether new land can be opened economically to irrigation. Government agencies concerned with water resource development have disparate estimates on the acres of land that could be irrigated economically within the criteria listed. Any estimate, however, is more likely as not to inflate as the world demand for food grows with population and the prices hungry people are willing to pay. The state Department of Natural Resources estimates that probably 500,000 acres in the Yellowstone Basin will be irrigated someday. The Bureau of Reclamation, however, estimates that new irrigation development in the Northern Plains region will not exceed 100,000 acres. There are other projections; all can be related to Montana's potential future in coal development.

To determine the amount of water needed for future irrigation developments, cropping patterns and the efficiency of water delivery systems must be estimated. It will be assumed that future irrigated lands will have cropping patterns like those of today and that the future delivery systems will be as efficient as those now in operation.

> Based on what we (DNR) know about cropping patterns and consumptive water requirements for different crops, an average of approximately 1.47 acre-feet per acre per year is consumed by these crops. Information on irrigation and deliver system efficiencies indicate a diversion requirement of approximately 5.00 acre-feet per acre year. (our emphasis)

Approximately 50 per cent of this diversion requirement is returned to the river system as a return flow, but "information on the time and location on availability return flow for reuse is not predictable with current technology. All that's known is its later and downstream."

The Department of Natural Resources (DNR) has classified over 2.1 million acres of land as potentially irrigatable in the Yellowstone Basin. "This classification is based only on soil and topography as to the ability to sustain continued agriculture. It does not consider water supply, accessibility or economics. However, we know all of it will never be irrigated so (we are) assuming an additional 500,000 acres of irrigation (would) be a more probable figure." According to DNR, water requirements for potentially irrigable lands in the Yellowstone Basin would be approximately 2.5 million acre-feet a year. Of this 2.5 million acre-feet of water, 1.25 million would flow back to the river.

The Missouri River Basin (MRB) Comprehensive Framework Study, written by a federal inter-agency task force, estimated that more than 1.3 million acres in the Yellowstone and Upper Missouri River Basins will be irrigated between 1970 and 2020. The bulk of this irrigation demand is projected to occur between now and 2000. Projecting from the diversion requirement of 5.00 acre-feet per acre per year, more than 6.5 million acre-feet of water would be demanded for irrigation if MRB's forecast came true. In a dry year (there is a 50 per cent chance of this in any year), total demand would jump 925,130 acre-feet to a grand total of more than 7.4 million acre-feet a year.

Another federal inter-agency task force, the Montana State Study team for the Western U.S. Water Report, disagreed with the MRB probable irrigation figures. "It is doubtful that 1,000,000 acres could be economically developed in the State of Montana in the future. Half that amount would be more realistic. Potential developments in the amount of 487,000 acres have been specifically identified." Using present information about average irrigation water demand, over 1.7 million acre-feet of water would be needed to supply this level of development. With additonal demand for a dry year (50% chance of occurring) the total demand would be a little less than 2.0 million acre-feet per year.

The Northern Great Plains Resource Program (NGPRP) does not consider the future irrigation development outlook to be promising. As the water work group report of the NGPRP put it, "under existing project formulation criteria, there are essentially no (irrigable land) units which meet federally-funded economic justification within the Yellowstone Basin." They determined that there will be "some amount of private and state-assested irrigation in the future, but it is not expected to exceed 100,000 acres." (This figure is for eastern

Montana, western North Dakota, and northern Wyoming.) What is considered as unjustifiable for economic development today, may be good business under market conditions 20 or 30 years from now when energy conversion plants built in this decade would still be consuming prodigious quantities of what might have been irrigation water. Applying DNR's figures for crop requirements and water delivery systems to Bureau of Reclamation's conservative estimate, however, reveals that even a moderate amount of irrigated land in the Northern Plains would require approximately 500,000 acre-feet of water per year. In the case of a dry year (one in every two) the diversion expands 71,000 acre-feet (0.71 acre-feet per acre per year) for a total requirement of 571,000 acre-feet per year.

Summary of Future Irrigation Water Demand Projections

Area Considered	NGPRP (coal region-- eastern Montana, northern Wyoming, western North Dakota)	Western Water Plan (Upper Missouri and Yellowstone river basins in Montana)	DNR (Yellowstone river basin-- Montana)	MRB (Upper Missouri and Yellowstone river basins)
Acres of potentially irrigable lands, present-2020	100,000	341,000	500,000	1,303,000
Diversion Required (Acre-feet of water per acre per year)	500,000	1,705,000	2,500,000	6,515,000
Dry Year-- Total diversion with 50% chance of occuring.	571,000	1.947,110	2,855,000	7,440,130
Amount needed in addition to usual requirements.	(71,000)	(242,110)	(355,000)	(925,130)

NGPRP - Northern Great Plains Resource Program
Water Plan - Western U.S. Water Plan; Montana State Study Team Report
DNR - Department of Natural Resources and Conservation, State of Montana Agency
MRB - Missouri River Basin Comprehensive Framework Study

Water Availability

The Northern Great Plains Resource Program's Water Work Group Draft Report states that, "industry could obtain something in excess of 3 million acre-feet annually in the Upper Missouri Basin (includes Yellowstone) without conflicting with other needs, providing adequate new storage is developed to support the necessary diversions and providing that aqueducts are constructed from points of water availability to points of use." This estimate allows for 500,000 acre-feet of water for future irrigation use.

If coal development can be limited to the extensive level of development then there would be no need for building storage dams. However, a rather extensive aqueduct system would have to be built to transport water across various regions of the state and to Wyoming.

The moderate scenario could be approximated while allowing for only 100,000 acres of new irrigation development in the Yellowstone Basin, and still not require storage dams. Any limitation of water supply to potential irrigation areas should be seen as a 40-year commitment.

Following is a summary of the total water demand given various levels of irrigation and coal development.

Summary of
ENERGY AND IRRIGATION WATER MATRIX
POTENTIAL LEVEL OF IRRIGATION DEVELOPMENT
(in 1,000's of acre-feet per year)

Levels of Development	None	NGPRP Estimate[1]	Water Plan[2]	DNR[3]	MRB Report[4]
No energy development		500	1705	2500	6515
Base energy development 4 power plants	92	592	1797	2592	6607
Water already contracted for industrial development. (enough for 4 power plants and 4 gas plants.)	228	728	1933	2728	6743
Most Probable 4 power plants 6 gasification plants	272	772	1977	2772	6787
Extensive 3 power plants 15 gasification plants	519	1019	2224	3019	7034
Total: 50% of request and contracts 2 extensive developments, or possible combination of 6 power plants 30 gasification plants	1051.225	1551.225	2756.225	3551.225	7566.225
Total request and contracts 4 extensive developments or possible combination 12 power plants 60 gasification	2102.450	2602.450	3807.450	7102.450	8617.45

1. NGPRP - Northern Great Plains Resource Program
2. Water Plan - Wester U.S. Water Plan; Montana State Study Team Report
3. DNR - Department of Natural Resources and Conservation, State of Montan Agency
4. MRB - Missouri River Basin Comprehensive Framework Study

PETROLEUM

Reserves

Montana's crude oil proved reserves (as of January, 1974), totaled 334 million barrels, less than one per cent of total U.S. recoverable reserves.[1] Most of the oil is found in:

1. Williston Basin
2. Eastern counties (Big Horn, Rosebud, Powder River, Carter, Yellowstone, Musselshell, Petroleum, and Garfield).
3. North-central counties (Toole, Glacier, Liberty, Pondera and Teton).

The Montana Board of Oil and Gas Conservation estimates that only a small portion of the total oil resource has been discovered. Increasing prices of domestic crude and new taxes on Canadian crude will tend to encourage exploratory activity in the state.

Production

Production of petroleum in Montana steadily increased to a peak of 48.5 million barrels in 1968 with the 1967 discovery of the Bell Creek Field.[2] By 1972 production had declined to 33.9 million barrels (mainly the result of decreasing production of Tiger Ridge Field).[3] Montana produces about one per cent of U.S. crude petroleum.[4]

Montana has nine oil refineries, three of which are in the Billings area. Table I* shows the location and crude capacity of the refineries.

*Tables and figures follow text of section.

Of the 48.5 million barrels of crude refined in Montana in 1972, 9.0 million barrels (18.7 per cent) were indigenous, 13.7 million barrels (28.2 per cent) were imported from Canada, and 25.8 million barrels (53.1 per cent) were imported from Wyoming.[5] In 1973, 19.2 per cent of the crude refined was indigenous, 31.13 per cent Canadian and 49.85 per cent from Wyoming. There is no Middle Eastern or South American crude oil refined or sold in Montana.

Transport

Most Montana crude is transported from the field to the refinery by pipeline, although some moves by tank car, truck, or rail. Wyoming and Canadian crude is transported to Montana by pipeline.

Tables II and III show the 1968 pipeline mileage data for Montana and 1972 refinery receipts of crude by transportation mode.

TABLE II - PIPELINE MILEAGE DATA (1968)

Crude gathering lines	626 miles
Crude trunk lines	1,199 miles
Refined products lines	674 miles
TOTAL	2,499 miles

Source: U.S. Petroleum Facts and Figures, 1971 Edition (American Petroleum Institute).

TABLE III - 1972 REFINERY RECEIPTS OF CRUDE (million barrels)

Domestic Intrastate Pipeline	12.6
Tank Cars and Trucks	.7
Domestic Interstate Pipeline	16.4
Foreign Pipeline	11.5
TOTAL	41.2

Source: Mineral Industry Survey, January 1973 (U.S. Department of the Interior).

Consumption

Consumption of petroleum in Montana has been gradually increasing since 1960 (See figure 2)

Consumption of petroleum by the transportation sector is the largest use in Montana and has a growth rate of 1.92 per cent per year.[6] The use of gasoline for automobiles is the largest single use of petroleum products in Montana.[7] Not only have the number of Montana registered vehicles been increasing, but also the average gasoline consumption per automobile has been increasing (due to larger vehicle size, weight, and horsepower).

The automobile is the major means of transportation in the state. With sparse population and isolated urban areas, Montana's potential for mass transportation is limited. The trend toward increased use of the automobile as the basic mode of transportation has been encouraged by land use patterns in Montana (suburban housing developments, vacation homes, automobile-oriented central business districts). In 1972, 52.5 trillion BTU were used by gasoline powered vehicles on the state's highways.[8]

Rail is an efficient mode for transport for passengers and freight. See Table IV for energy efficiency comparisons for different modes of transportation. The total use of diesel fuel by railroads in 1972 was 10.57 trillion BTU.[10] In 1972 six railroads in Montana were providing freight service. Burlington Northern and Chicago, Milwaukee, St. Paul and Pacific carry 98 per cent of the freight in Montana (based on ton miles traveled).[11]

The National Railroad Passenger Corporation (Amtrak) provides two east-west passenger trains in the state. On the northern route, the Empire Builder provides daily service. About 18 per cent of the train's passengers boarded or debarked in Montana.[12] The southern route, the North Coast Hiawatha, which used to provide only tri-weekly service, has begun daily service experimentally. About 38 per cent of its passengers boarded or debarked in Montana.[13]

The main rail lines of the state are shown in Figure 4.

In 1972, trucks and buses in Montana consumed 8.82 trillion BTU of diesel fuel; off-highway uses such as farm machinery consumed an additional 2.81 trillion BTU.[14]

The purchase of aviation fuel in Montana has fluctuated but the general trend is an increase in consumption. Airplanes purchased 4.5 trillion BTU of fuel in Montana in 1972.[15] Increases in the number of registered general aviation aircraft, and heavier commercial traffic at commercial airports have contributed to increased aviation fuel consumption.

The use of petroleum for non-transportation uses is increasing at a rate of 0.4 per cent per year.[16] The slow growth rate is the result of the decline of oil as fuel for home heating and increased industrial use of oil for fuel and lubrication. In 1960, 38,444 homes used fuel oil or kerosene for heating and by 1970, this had decreased to 29,950 homes.[17] Sales of heating oils decreased from the 1962 peak of 2.09 million barrels in 1968.[18] During this same period, industrial uses of oil for fuel and lubrication increased.

Table I

Location and Crude Capacity of Montana Oil Refineries

Name	barrels/calendar day	barrels/stream day
Big West Oil Co. - Kevin	4,867	5,500
Continental Oil Co. - Billings	45,500	48,000
Diamond Asphalt Co. - Chinook	N/A	1,000
Exxon Co. - Billings	45,000	49,000
Farmer's Union Central Exchange - Laurel	30,000	33,000
Jet Fuel Refinery - Mosby	1,000	N/A
Phillips Petroleum - Great Falls	5,700	N/A
Spruce Oil Corp. - Wolf Point	2,500	2,475
Westco Refining Co. - Cut Bank	3,982	4,500

Source: Oil and Gas Journal, April 2, 1973.

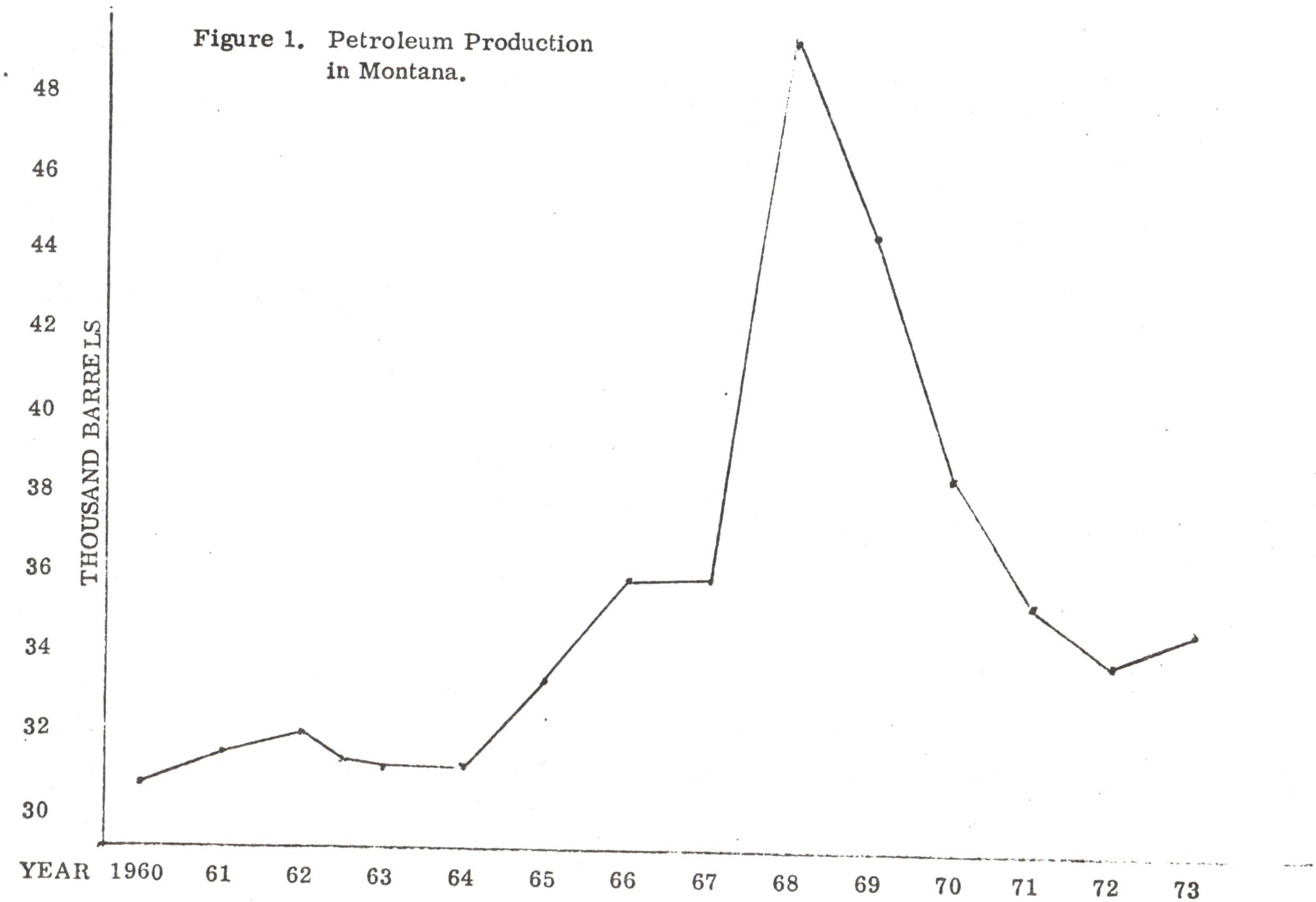


Figure 1. Petroleum Production in Montana.

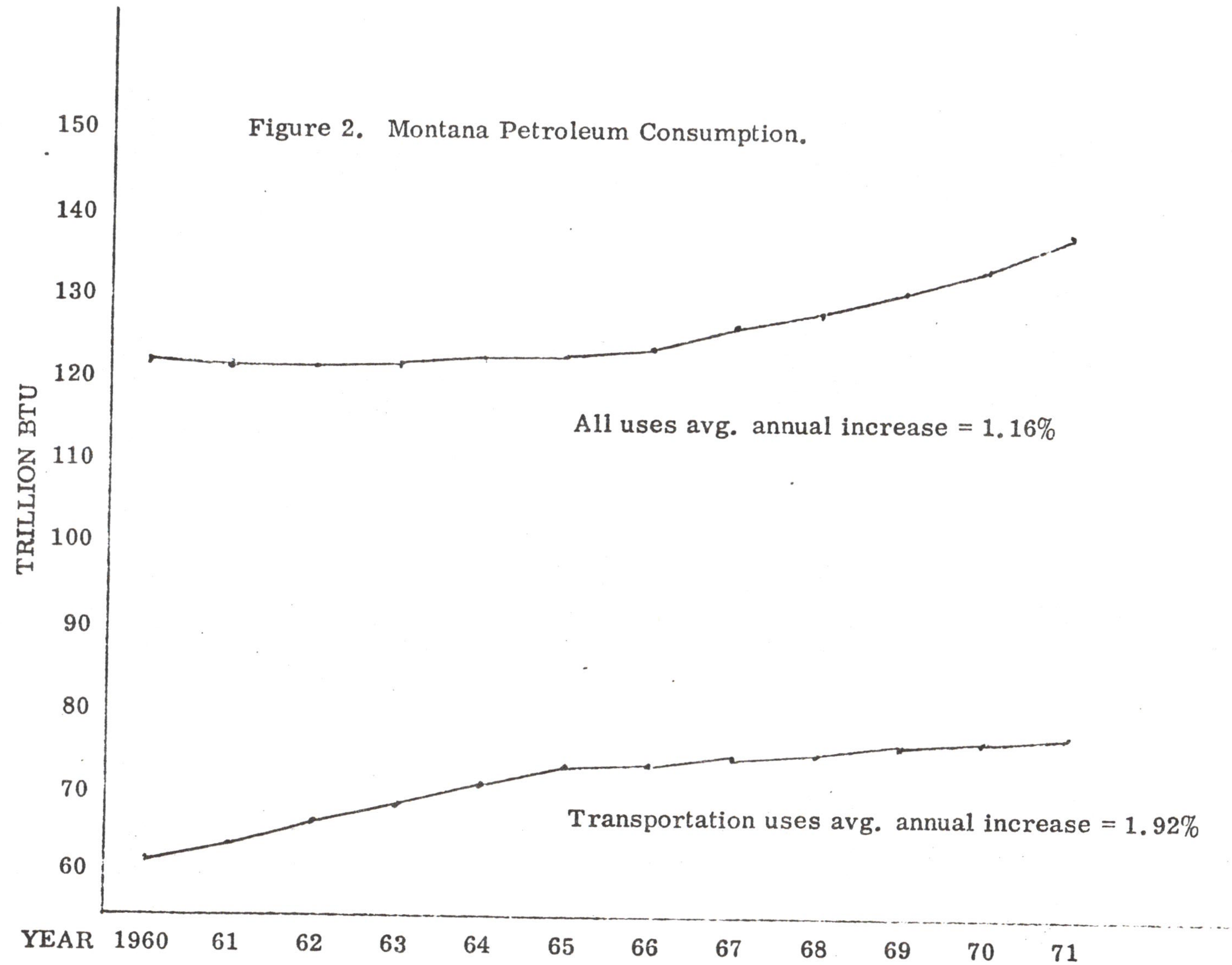


Figure 2. Montana Petroleum Consumption.

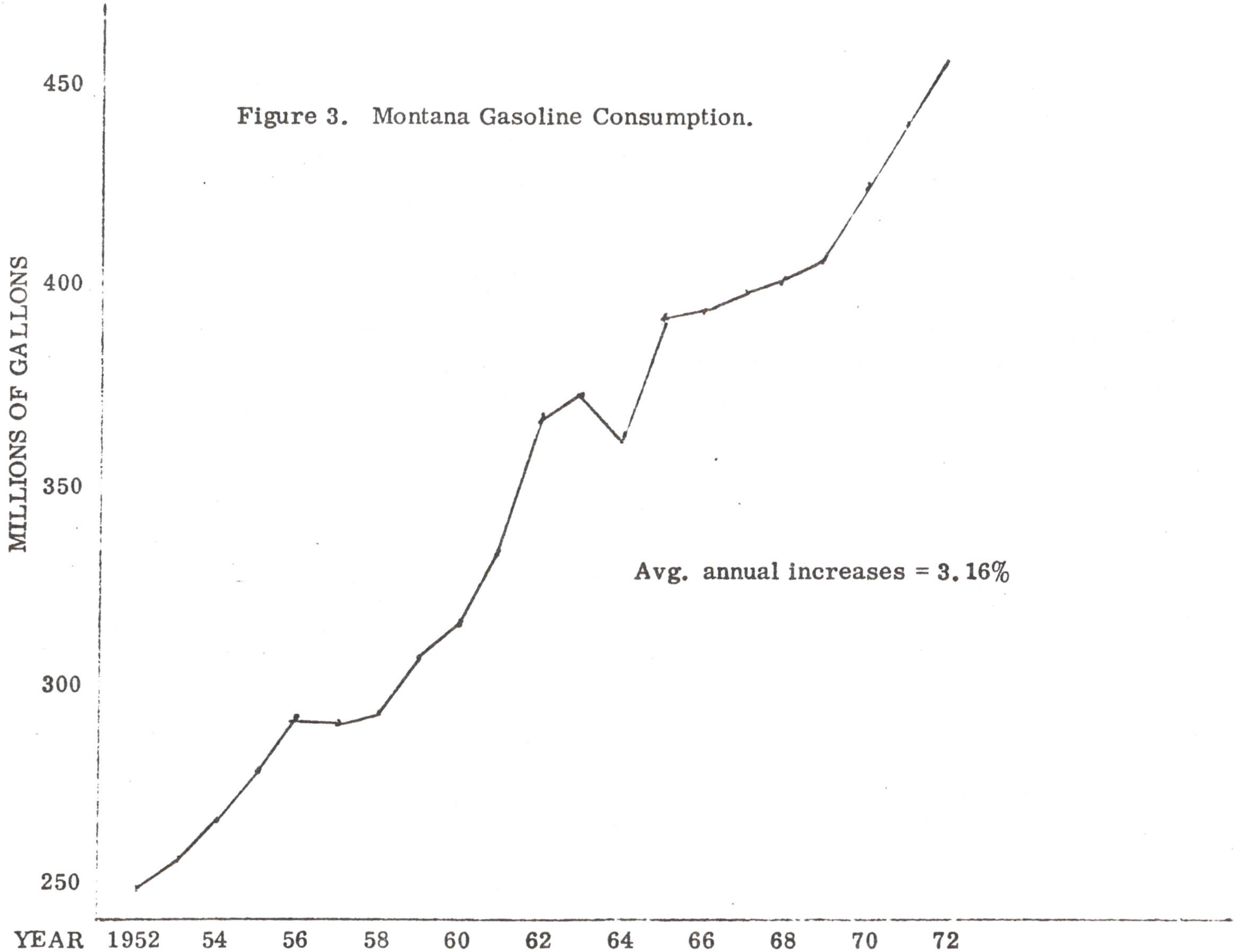


Figure 3. Montana Gasoline Consumption.

FIGURE 17 RAILINES OF MONTANA

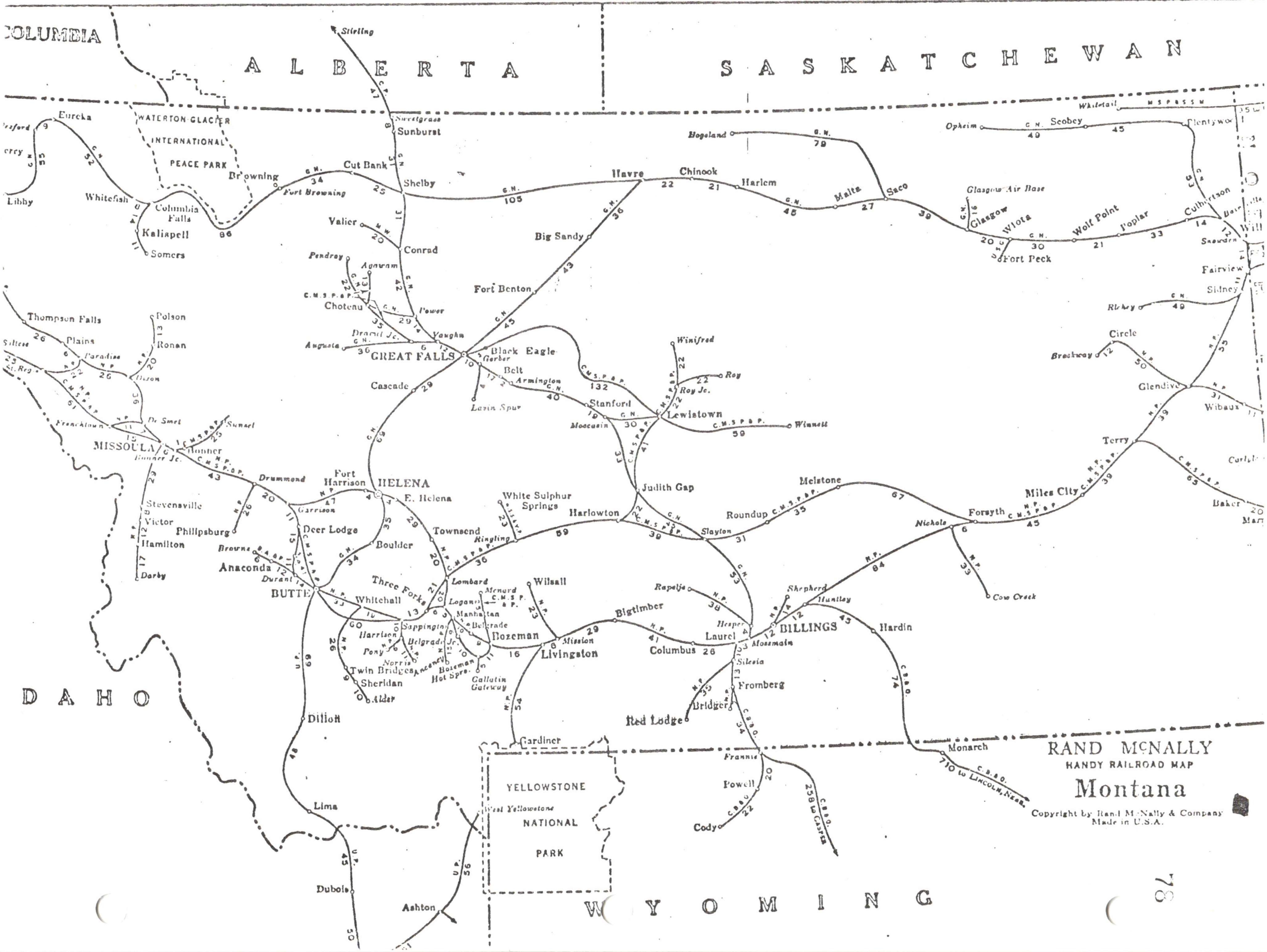


TABLE II

Montana Motor Vehicle Registration

Passenger cars	286,100
Trucks	171,100
Personal Trailers	25,362
Motorcycles	25,692
TOTAL	508,254

Source: Registrar of Motor Vehicles, Deer Lodge, Montana, 1973.

Table III

Montana State Air Carrier Airport
Enplanement Forecast[a]
(Thousands of persons)

Average Annual % growth 1970-92		1970	1975	1982	1992
7.6	Billings	197	227	478	984
8.8	Bozeman	22	34	72	141
5.9	Butte	39	49	76	131
7.9	Great Falls	130	195	345	700
6.9	Helena	23	31	53	97
12.0	Kalispell	8.2	12.9	28	88
6.9	Missoula	38	52	89	162
12.0	West Yellowstone	3	9	19	59

[a]Enplanements only are shown, not arriving passengers.

Source: Montana Aeronautics Commission, Worthie Rauscher.

Table IV

Energy Efficiency in Transportation (1972)[a]

Freight - Inter-city

Mode	BTU/ton-mile
pipeline	450
waterway	680
railroad	670
truck	2,800
airplane	42,000

Passenger - Inter-city

Mode	BTU/passenger-mile
bus	1,600
railroad	2,900
automobile	3,400
airplane	8,400

Passenger - Intra-city

Mode	BTU/passenger miles
bicycling	200
walking	300
bus	3,800
automobile	8,100

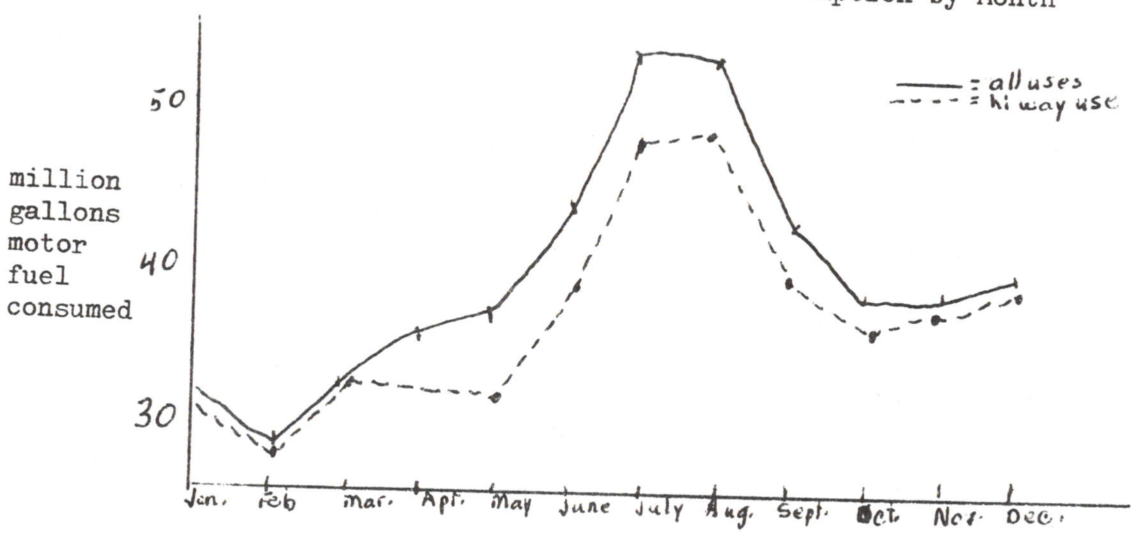
Table IV

Energy Consumption in Montana
Transportation Systems, 1972

Transportation Mode	10^{12} BTU
Gasoline-powered vehicles	52.50
Diesel-powered trucks and buses	10.57
Railroad	8.82
Air	4.50
TOTAL	76.39

Source: Mineral Industry Surveys: Sales of Fuel Oil in 1972; and Montana Department of Revenue 1972 tax statistics.

Figure 4 - 1971 Montana Motor Fuel Consumption by Month



Total= 471 million gallons for all uses

Total= 433.5 mil gal. for hiway use

Total= 30.6 million gallons for non hiway use

Source: U.S. Dept. Transportation Highway Statistics 1971

Table V shows consumption of petroleum by refinery type for non-transportation uses.

Table V

Montana Non-transportation Petroleum
Energy Consumption (1972)

Type of Petroleum		Energy Content (10^{12} BTU)
Kerosene		2.18
Distillate type oils		13.02
Residual type oils		9.23
LPG		6.77 (1969)
	TOTAL	31.20

Source: Bureau of Mines 1972 Mineral Industry Surveys.

Natural gas found with oil was flared before extensive pipeline and storage facilities for natural gas were developed. The convenient, clean-burning fuel then moved into the markets of other fossil fuels; consumption was encouraged by the low FPC-regulated wellhead prices. While consumption increased because of the flexibility, convenience and low cost of natural gas, development of new gas reserves lagged because of increased exploratory drilling costs and the low wellhead prices.

Reserves

Although gas reserves are not as abundant as coal in recoverable BTUs there are considerable gas reserves in Montana. Estimated proved gas reserves in Montana total two trillion cubic feet.[1] The Montana Board of Oil and Gas Conservation estimates that the total recoverable gas resource may total between six and ten million cubic feet.[2] Table I estimates recoverable proved gas reserves for the U.S. and Montana for the years of 1960 and 1970.[3]

TABLE I -- RECOVERABLE PROVEN GAS RESERVES
(Billion Cubic Feet)

	1960	1970
Montana	626	1,100
United States	263,759	290,746

The ultimate storage capacity of gas reserves in underground storage wells in 1971 was estimated at 213 billion cubic feet.[4]

Production

Montana has six natural gas processing plants. Natural gas production over the past 20 years has been variable, depending upon such factors as exploration successes, the availability of Canadian gas, demand, and federal regulation. Figure I*shows marketed natural gas production from 1960 to 1971. The increase in production in 1970 was a result of the discovery and development of the Tiger Ridge Field. Montana power now makes loans to producers to encourage drilling in Montana for natural gas. Production had gone down from the 1971 high, but now production and exploration have again increased. Almost 58 billion cubic feet of natural gas was produced in Montana in 1973.[5]

Wellhead prices for gas in interstate commerce are regulated by the Federal Power Commission. The regulated prices are determined by cost plus a reasonable profit margin and allow consumers to receive gas at rates lower than the free market price.

Consumption

Since 1930 Montana has annually consumed more gas than has been recovered. Only one out of every 14 wildcat drillings in 1972 was a producer. Figure 2 shows the relative consumption, production and import of natural gas from 1960 to 1971. In 1972, 77,348 million cubic feet of natural gas were consumed in Montana.[6]

The two major gas suppliers in Montana are Montana Dakota Utilities Company (MDU), serving the eastern part of the state, and Montana Power Company, serving the central and western part. Rural areas without gas service rely on bottled gas, oil, or electricity for cooking and heating.

MDU receives its gas from fields in Wyoming, Montana and the Dakotas. Montana Power, accounting for 70 per cent of retail gas sales in the state, receives only 20 per cent of its gas from Montana fields. The remaining

*Tables and figures follow text of section.

80 per cent is piped in from fields in southern Alberta because it is easier and less expensive to import cheap Canadian gas than to develop Montana reserves . Sixty per cent of Montana Power natural gas is from Canadian sources the power company has developed or purchased in Alberta.[7] Out of state firms, however, have developed Montana reserves for shipment to the Midwest.

The National Energy Board of Canada which has the authority to determine established reserves, market requirements and exportable surpluses for Canada has cut back exports to Montana after finding Canadian 30-year reserves deficient by 1.1 trillion cubic feet. The policy of assuring future Canadian domestic supplies first resulted in decreased exports as well as increased prices and royalties. However, additional drilling has proven enormous reserves of gas in the MacKenzie Delta and Artic Islands, so there is some optimism about being able to obtain future gas supplies from Canada.

The consumption of gas has increased in all sectors of the economy. Because of the low cost and convenience of gas heat, many Montana homes now use it instead of coal, wood or oil heat. In 1950, 43 per cent of Montana homes were gas heated. By 1970, 73 per cent of Montana homes were gas heated.[8]

Industrial use of gas is growing at a faster rate than residential use in the state (Figure 3). Table II shows the quantity of gas used by different sectors of the Montana economy. The Anaconda Company is the largest user of gas in the state; in 1972, it consumed 12,649,000 million cubic feet (MCF) for its operations at Butte and Anaconda and another 515,000 MCF at its Columbia Falls aluminum plant.[9] The new Arbiter copper reduction plant at Anaconda will use an additional 1,824,000 MCF per year when it begins operation.[10] The second largest user of natural gas is the Hoerner-Waldorf Corporation paper plant near Missoula. This plant used 4,428,000 MCF in 1972.[11] A new plywood plant in Bonner, now being constructed by Champion-International's U.S. Plywood Division, and a proposed 50 per cent expansion of Hoerner-Waldorf will also use large amounts of natural gas.

Some additional requests for industrial natural gas have been denied by Montana Power Company because of the uncertainty of receiving additional Canadian gas.

The generation of electricity consumes only small amounts of natural gas in the state. MDU operates a 20 megawatt turbine near Miles City for reserve electricity which uses natural gas. Small amounts of gas are used in the coal-fired J. E. Corette plant in Billings for flame stabilization.[12] Montana Power's Frank Bird plant can be run on either gas or oil, but due of the scarcity of natural gas, is fueled by oil.

Transportation

Montana has a total of 6,130 miles of gas utility main pipelines, including 1,150 miles of field and gather pipelines, 2,730 miles of transmission pipelines, and 2,250 miles of distribution pipelines.[13]

Northern Natural Gas Company and Montana Power Company both have gas pipelines to Montana from Canada. MDU has a pipeline from North Dakota and Wyoming.

Imports and Exports

Montana does export some natural gas but is a net importer. Imports of natural gas have steadily increased from 21.2 trillion BTU in 1960 to 61.2 trillion BTU in 1971.[14] (See figure 2)

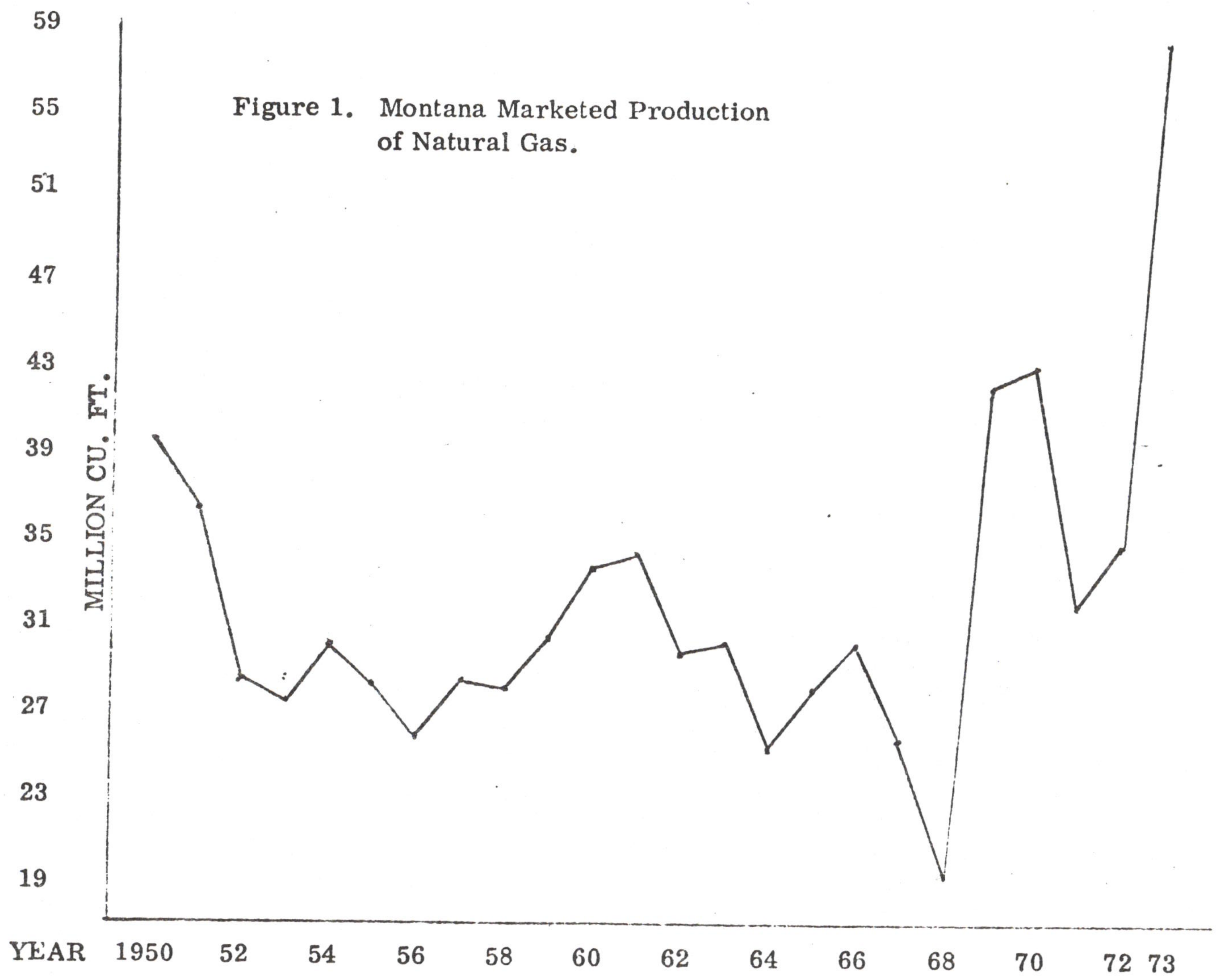


Figure 1. Montana Marketed Production of Natural Gas.

Figure 2 Natural Gas in Montana

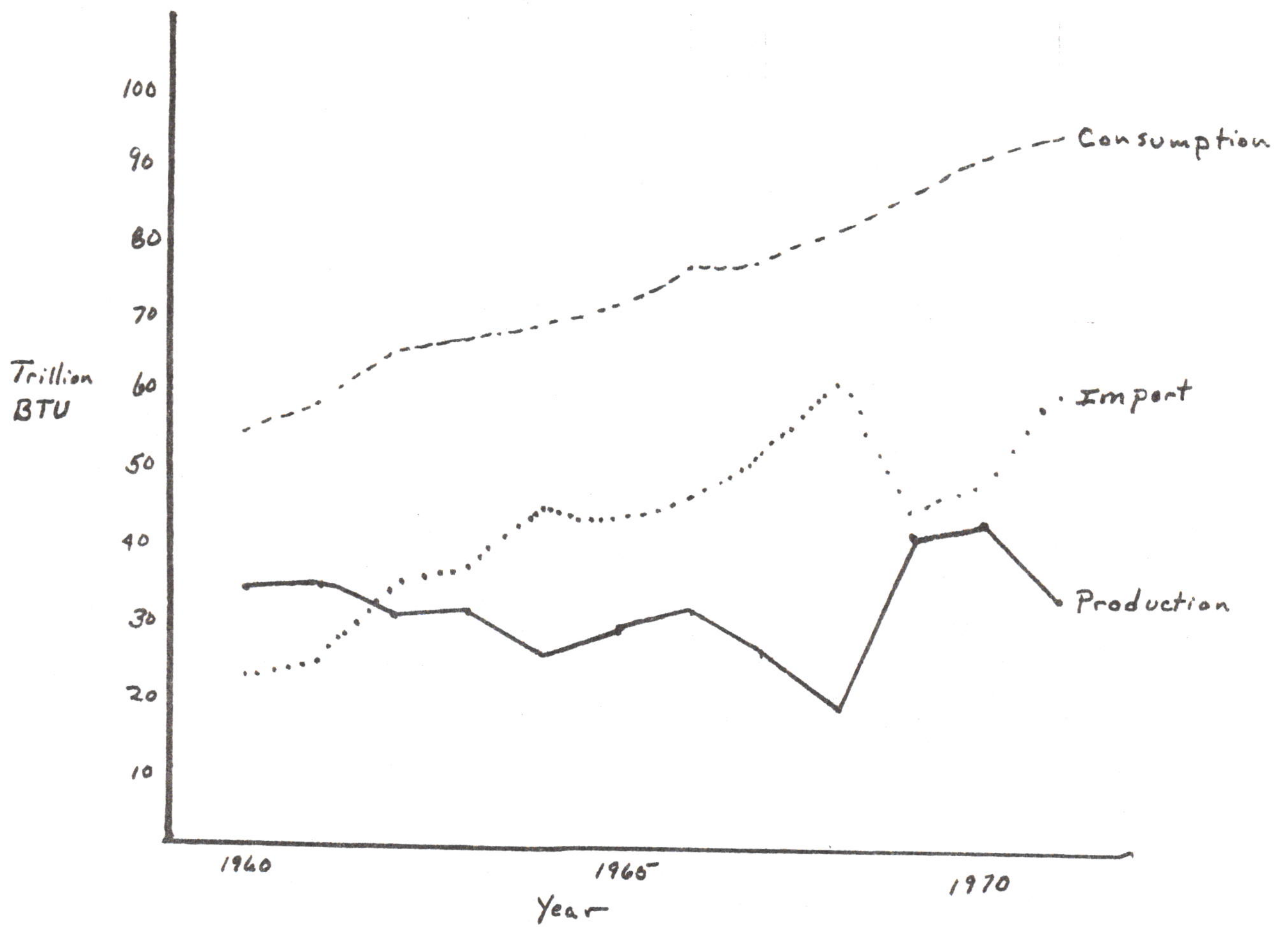


Figure 3. Montana Natural Gas Consumption.

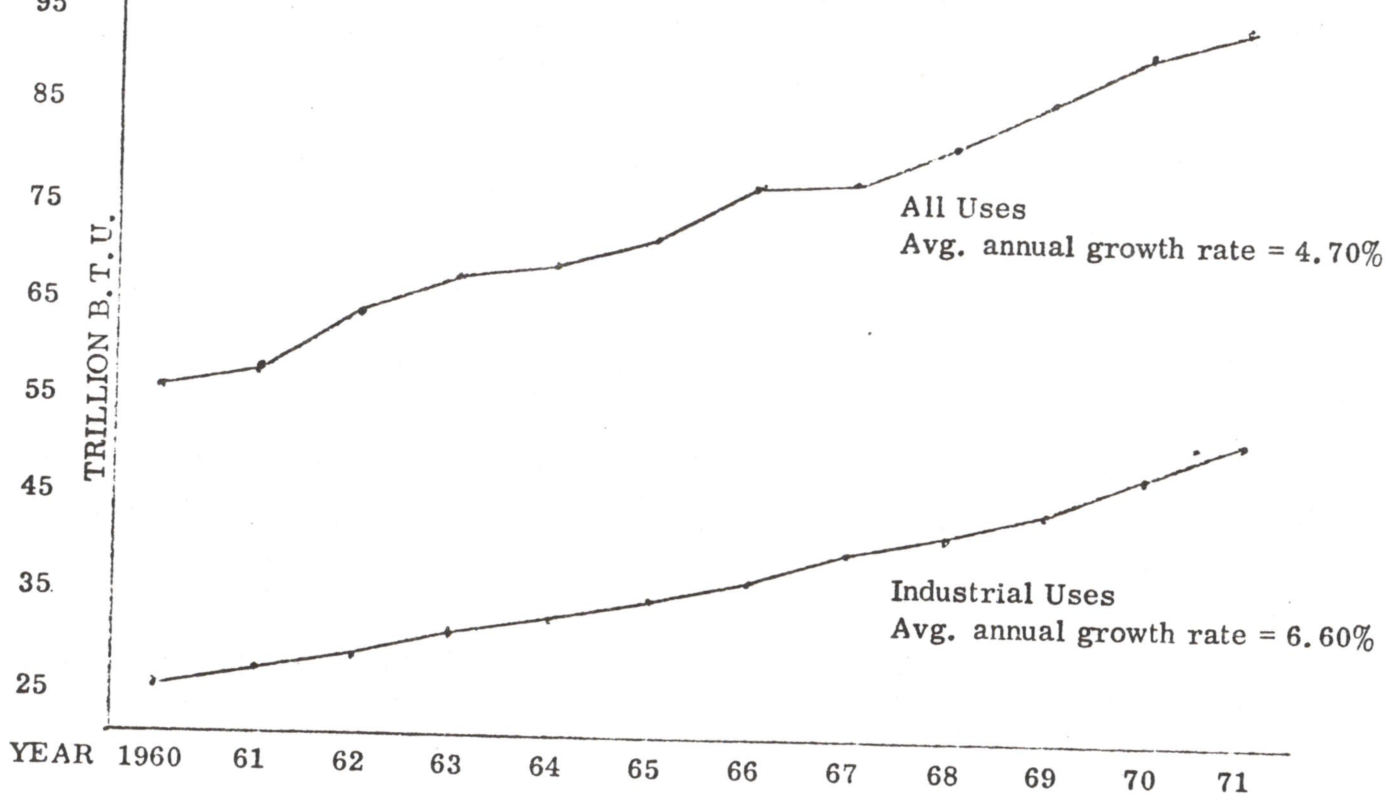
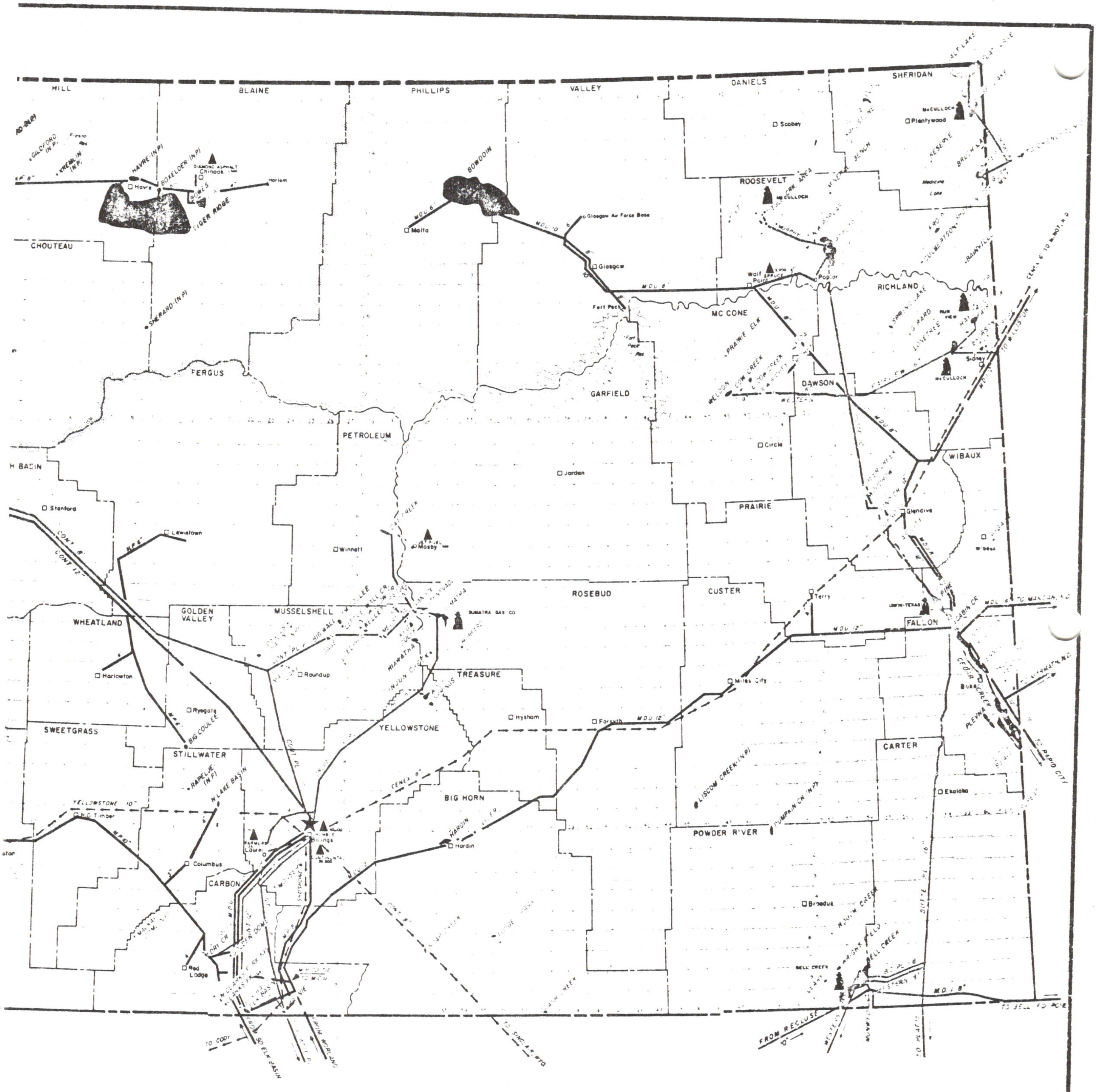


Table II

Quantity and Value of Natural Gas Delivered
to Montana Consumers: 1972

	Quantity (million) cubic feet)	Value (thousands of dollars)
Residential	23,787	22,978
Commercial	16,521	11,416
Industrial	33,192	12,679
Electric Utilities	1,218	418
Other Consumers	2,630	1,273
	77,348	48,764

Source: Bureau of Mines Mineral Industry Surveys, 1972.



MONTANA
OIL AND GAS FIELDS, PIPELINES AND REFINERIES
1971

BOARD OF OIL AND GAS CONSERVATION

Figure 3

OIL AND NATURAL GAS EXPLORATION POTENTIAL IN MONTANA

Future oil exploration potential in Montana depends on regional trends in oil and gas production. Location of Alberta oil fields to the North tend to be aligned with those of the Wyoming, Colorado and Utah fields to the South, but there appears to be a Montana continuity readily observed in the Rocky Mountain Region Oil and Gas Field Map, published in the April 1974 issue, Western Oil Reporter*.

Favorable geologic basins are analogous to those of adjacent states, are in Montana. Most of the inexpensively-drilled, shallow geologic structures and potential oil traps have been drilled in Montana.

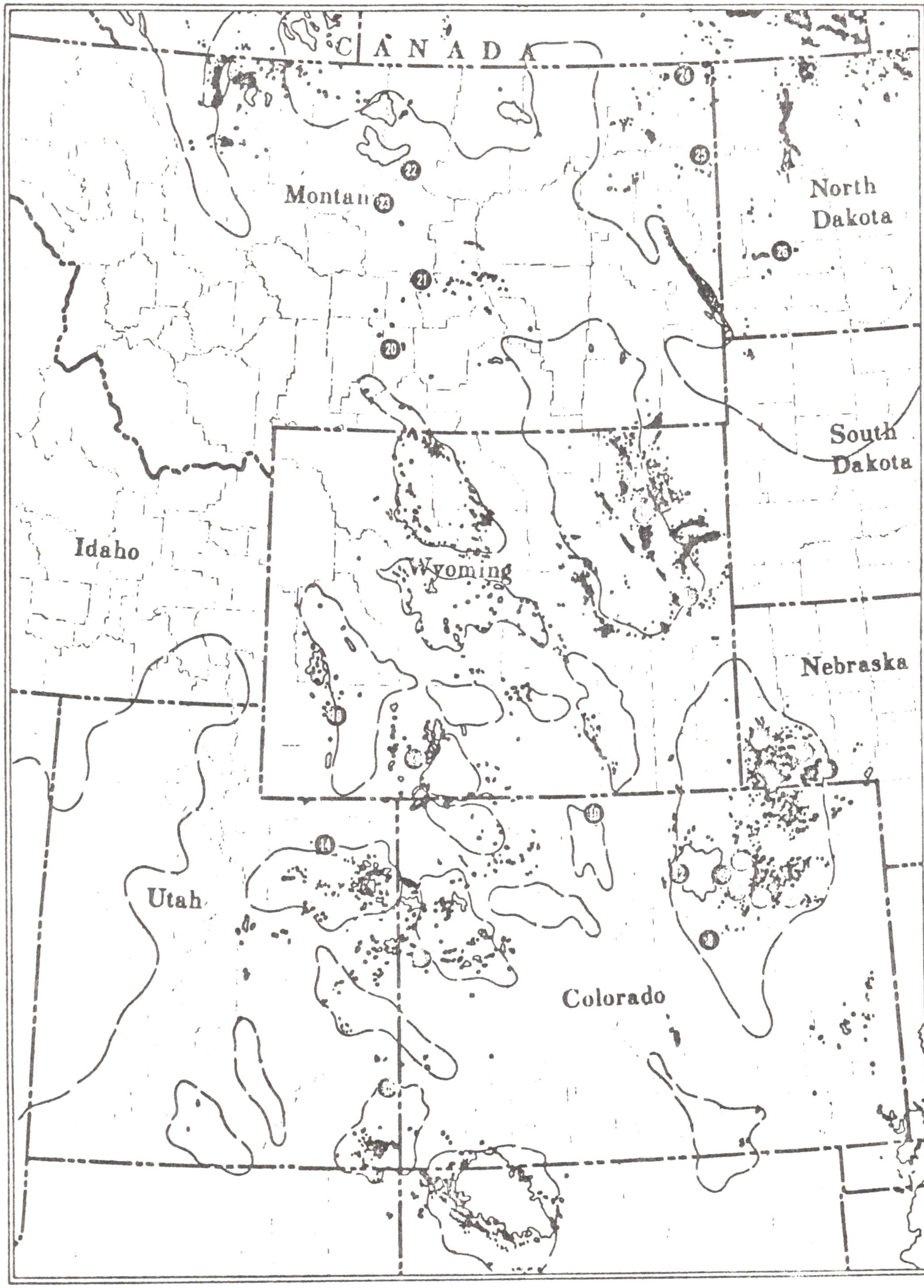
The Rocky Mountain states are known for their generally small geologic structures and traps, some occurring at great depths. Although some of these are still being explored in Montana and adjacent states, most current domestic exploration drilling activity is on the United States Continental Shelf areas where large reserves are likely in single pools. Continental Shelf exploration is risky; costs are high. But the anticipated profits also are great. For these reasons, only limited amounts of risk capital have been available for exploration activity recently.

Only in the Williston Basin has Montana's deep-oil producing potential been well tested. Deep tests are expensive, requiring a favorable business climate. Deep tests can reveal significant new reserves, which could yield volumes of oil and gas exceeding previous discoveries in Montana. Virtually untested geologic basins of the southwest and northwest Montana also could yield sizeable new oil and gas reserves. Exploration activity in large areas of central and northern Montana also could likewise lead to sizeable new oil reserves.

* Included here with permission of Mr. Donald Hart, Publisher.

Expanded use of secondary and tertiary oil recovery techniques easily could yield new reserves equal to those already produced to date in Montana.

Because of Montana's untapped oil potential, a conservative estimate of potential developable reserves exceeds 2 billion barrels of oil and 2,500 billion cubic feet of natural gas. Such development would require new exploration and production incentives, however.


CANADA
Montana
North Dakota
South Dakota
Idaho
Wyoming
Nebraska
Utah
Colorado

ENVIRONMENTAL IMPACTS OF OIL AND GAS

Exploration and Production

Exploration for oil and gas can cause temporary land disturbances. Significant problems are blowouts which can result in the escape of oil or gas, air pollution resulting from the flaring of "sour" gas or burning oil in waste pits (most reject gas which used to be flared is now reinjected into the well), potential ground and surface water contamination resulting from the disposal of brines which are sometimes produced with oil (this problem may be solved by removing the salts from the water before disposal), and disposal of solid wastes (e.g., drilling muds).

Refining and Processing

The refining of crude oil or the processing of natural gas could pollute water, air, or soil, but most plants have adequate environmental pollution control equipment installed. Some solid and liquid by products (especially sulfur from gas processing plants) are potential environmental problems because they are corrosive or toxic and could be leached into the environment. These problems, however, can be controlled.

Transportation and Storage

A chief environmental problem associated with the transport of natural gas and petroleum has been the possibility pipeline ruptures or leakage. Oil spillage may contaminate surface waters and possibly hurt aquatic life; gas from pipeline leaks or breaks evaporates quickly but poses a significant fire hazard. Pipelines may interfere with wildlife migration patterns and water drainage. Stored oil and gas, of course, is always a fire hazard, and threatens the same impacts as transported fuel in the event of a leak.

OIL SHALE

One source of petroleum is oil shale, a fine-grained, compact sedimentary rock containing an oily substance called Kerogen. Formed from aquatic life (algae, spores, and pollen grains) and mixed with inorganic components of the shale, Kerogen is petroleum formed at inadequate pressure and temperature.

Unrefined oil shale has a variable composition, but in general has more nitrogen and less hydrogen than petroleum. Oil shale can be refined to yield fuel oils, diesel fuel, gasoline, jet fuel, and liquified petroleum gas (LPG) as well as oil by-products.

Oil shale yields at least 10 gallons of oil per ton or rock; most developed deposits yield between 25 and 65 gallons per ton.[1]

The U. S. has the world's largest oil shale deposit. Brazil has the second largest and China, USSR, Republic of the Congo, Germany, Italy, England, France, Sweden, Canada and Theiland have substantial oil shale reserves.[2] The most extensive and valuable U. S. oil shale reserves are found in Green River Formation in Colorado, Utah, and Wyoming.[3] The shale deposits in this formation cover about 16 million acres, some of them as deep as 7,000 feet. Most of the high-grade shale is found in the Piceance basin of Colorado which contains 80 billion barrels of recoverable shale oil. The shale deposits are more than 30 feet thick and have an oil content of about 30 gallons per ton.[4]

Very small and scattered oil shale deposits are found near Lewistown. Some have a yield of oil as high as 70 gallons/ton.[5]

Converting oil shale to petroleum-analogous products is not yet commercially feasible although there have been experimental oil shale plants in operation for some time. One of the most promising methods is the Toscoll process.[6] The oil shale is mined and crushed to half-inch pieces, preheated with hot flue gas, and mixed with hot ceramic spacers in rotating drum. The Kerogen is converted to hydrocarbon vapor by heating the crushed or to 900°C. The vapors are then drawn off, condensed and treated in conventional oil processing units. The ceramic spacers recycle to a heater. The processed shale is cooled, moistened and transferred to a disposal site.

The resulting crude oil is processed at regular oil refineries into gasoline, jet fuel, fuel oil, liquified petroleum gas and oil by-products. It can be processed to remove sulfur and nitrogen to produce high grade fuel oil or high quality raw material for natural gas production.

There are serious problems with shale oil--reclamation of shale waste-disposal areas and the high water requirements for the distilling process. About half of the water used in oil shale processing is sprayed on spent shale to keep the piles from eroding or blowing away. Runoff can be highly saline, making it unfit for irrigation or municipal consumption and perhaps a threat to wildlife.

HYDROELECTRICITY

Montana's extensive river systems have provided numerous hydroelectric dam sites for Bureau of Reclamation, Army Corps of Engineers, and private utilities development. Hydroelectric facilities still account for about 85 per cent of the generating capacity of the state (See Table I in Electricity Section). However, when Colstrip Units No. 1 and No. 2 are completed in 1976, the figure will drop to 66 per cent, even if Libby dam's generators are in full operation by that time.

Developed water power capacity in Montana totaled 1512 megawatts in 1968.[1] This was 43.2 per cent of the hydroelectric capacity of the Rocky Mountain states and 3.11 per cent of U.S. capacity.[2] Low cost hydroelectricity has encouraged the high per capita consumption of this energy in Montana and has encouraged energy-intensive industry.

Hydroelectric plants are relatively long lived and have low operating and maintenance costs and do not emit neither air nor water pollution. However, the aeration of water over spillways does increase dissolved nitrogen in the water below which may be harmful to fish.

Unlike nuclear and coal-fired plants, hydroelectric dams do not consume water. They can easily adjust to varying electric loads and are efficient.

If coal-fired power plants are built in eastern Montana, hydroelectric plants will be used more and more for system peaking capacity. Peaking capacity is defined as that part of a system only used during high electrical demand. The amount of peaking capacity available from a hydroelectric plant depends on operating limitations (rate and amount of change in reservoir elevations allowed by conflicting water uses), stream flows, reservoir storage level and capacity, and maintenance of downstream water quality and condition.

Hydroelectric capacity could be augmented by installing additional generators at existing power plant sites, developing pumped storage facilities and constructing dams. Adding generators to an existing site does not increase a reservoir's total energy storage but it can increase its peaking capacity. The possibility of additional turbines at Kerr Dam, at the south end of Flathead Lake, and at Ft. Peck Dam on the Missouri River is being studied by Montana Power Company and the Corps of Engineers respectively. The utilities have indicated, however, that they will be looking to coal, not water, to provide the bulk of new generating capacity.

Except for increasing the capacity of existing generator facilities, there is strong opposition to further development of electric dams in Montana. An additional 7781 megawatts could be developed. Table II in the electricity section shows a number of proposed hydroelectric facilities. However, Libby Dam (scheduled to begin production by 1975) is the only major hydroelectric project funded and under construction. One economically attractive project is the proposed Allenspur Dam near Livingston. Those opposing construction fear loss of fish and wildlife habitat and agricultural land, loss of the nation's longest remaining free flowing river, forced relocation of the people, and flooding of Yellowstone Park.

ELECTRICITY

Coordination with West Power Region

Most of Montana lies within the West Power Region which includes one-third of the United States land area (excluding Alaska and Hawaii). Characteristic of this region are large loads along the Pacific, long distances between load centers, and spotty distribution of energy resources.

Montana's electric power plants are coordinated with those of other states in the region by coordinating committees that represent utility companies. The desire for reliable and profitable electric energy has led to interconnections between these utilities. West Power Region utilities jointly own large generating plants, use seasonal load diversity to share reserves, and coordinate construction of power plants. The Montana Power Company is a member of the Pacific Northwest Coordination Agreement (PNCA), Western Systems Coordinating Council (WSCC), Associated Mountain Power Systems (AMPS), Rocky Mountain Power Pool (RMPP), and the Northwest Power Pool (NWPP).

A variety of fuels are used to generate electricity in the west region. Hydro-power has been a major contributor in the past, but steam-powered generation will become more important because remaining dam sites are scarce and usually environmentally undesirable.

In the west region, electricity sales are accounted for this way: 34 per cent in the industrial sector, 30.3 per cent in residential and rural uses, 20.3 per cent for commercial, 5.4 per cent for street and highway lighting, electrified transport and other uses, and 10 per cent lost in transmission.[1]

Power requirements for the west region show annual peaks in power use is in December, January, June, July, and August.[2] Daily peaks occur midday and early evening.[3]

Generation of Electricity in Montana

In 1970, about 87 per cent of Montana's electricity came from hydroelectric plants (the comparable national figure is less than 16 per cent). Conventional steam plants produced 13 per cent of the electricity for Montana (nationally: 82 per cent by conventional steam plants, and 2 per cent by nuclear and gas turbine plants).[5] This table summarizes the generation picture:

Generation (1970)
(Million Kilowatt-Hours)

	U.S.	Per Cent	Montana	Per Cent
Hydro	247,456	16	8,745	87
Conventional Steam	1,256,294	82	1,281	13
Nuclear Steam	21,797	1	---	--
Internal Combustion	6,062	1	---	--
Total	1,530,609	100	10,026	100

Source: U.S. Statistical Abstract (Dept. of Commerce) 1971.

Of the electricity generated by steam plants in Montana, 80 per cent is generated by coal, 18 per cent by natural gas, and 2 per cent by fuel oil.[6]

The generation of electricity by coal is discussed in the coal section of this report.

Generation by Fuel (1970)
(Million Kilowatt-Hours)

Fuel	U.S.	Montana
Coal	706,102	966
Fuel Oil	182,488	14
Gas	372,884	228
Nuclear	21,979	---
Total	1,283,271	1,208

Source: U.S. Statistical Abstract (Dept. of Commerce) 1971.

Capacity

Montana's per capita electric generating capacity in kilowatts is higher than per capita capacity in the U.S.

Capacity per capita (Kilowatts)	1968
Montana	2.64
U.S.	1.55

Source: 1970 Montana Data Book (Planning and Economic Development Division, Department of Intergovernmental Relations).

Montana's electricity capacity in 1968 was about 23 per cent of the Rocky Mountain States' capacity and .58 per cent of the U.S. capacity.[7]

Load Centers

The largest demand centers for electricity in Montana are Butte-Anaconda, Helena-Great Falls, Kalispell-Missoula, and Billings, with peak demands of 551, 260, 173, and 138 megawatts respectively.[8]

Exports

Montana is a net exporter of electrical energy. Of the 10.65 billion kilowatt-hours of electricity generated in Montana in 1971, 9.21 billion kilowatt-hours were sold in Montana, and 1.44 billion kilowatt-hours were exported. Some private utilities in the state must import electricity, however, particularly during peak load periods. Montana Power Company imports up to 23 per cent of its load annually.[9]

Some electricity generated in the state is not connected to Montana supply lines. There are three federal plants east of the Continental Divide including Fort Peck, Canyon Ferry and Yellowtail Dams. The power from these three installations is marketed by the Bureau of Reclamation. Much of the power from Yellowtail goes to rural electric cooperatives in the Dakotas. In addition, all the power from Washington Water Power Company's Noxon Dam in western Montana goes to Spokane, Washington.

Montana electricity exports will rise significantly when Colstrip units No. 1 and No. 2 are completed. Fifty per cent of the net Colstrip output (or 330-megawatts) will be exported to Puget Sound Power and Light Company. According to Montana Power, the cost per kilowatt-hour will be less with two units at Colstrip than with one. The proposed Colstrip units No. 2 and No. 3 are expected to export about 70 per cent of their energy to other Northwest Utilities.

Electricity Consumption in Montana

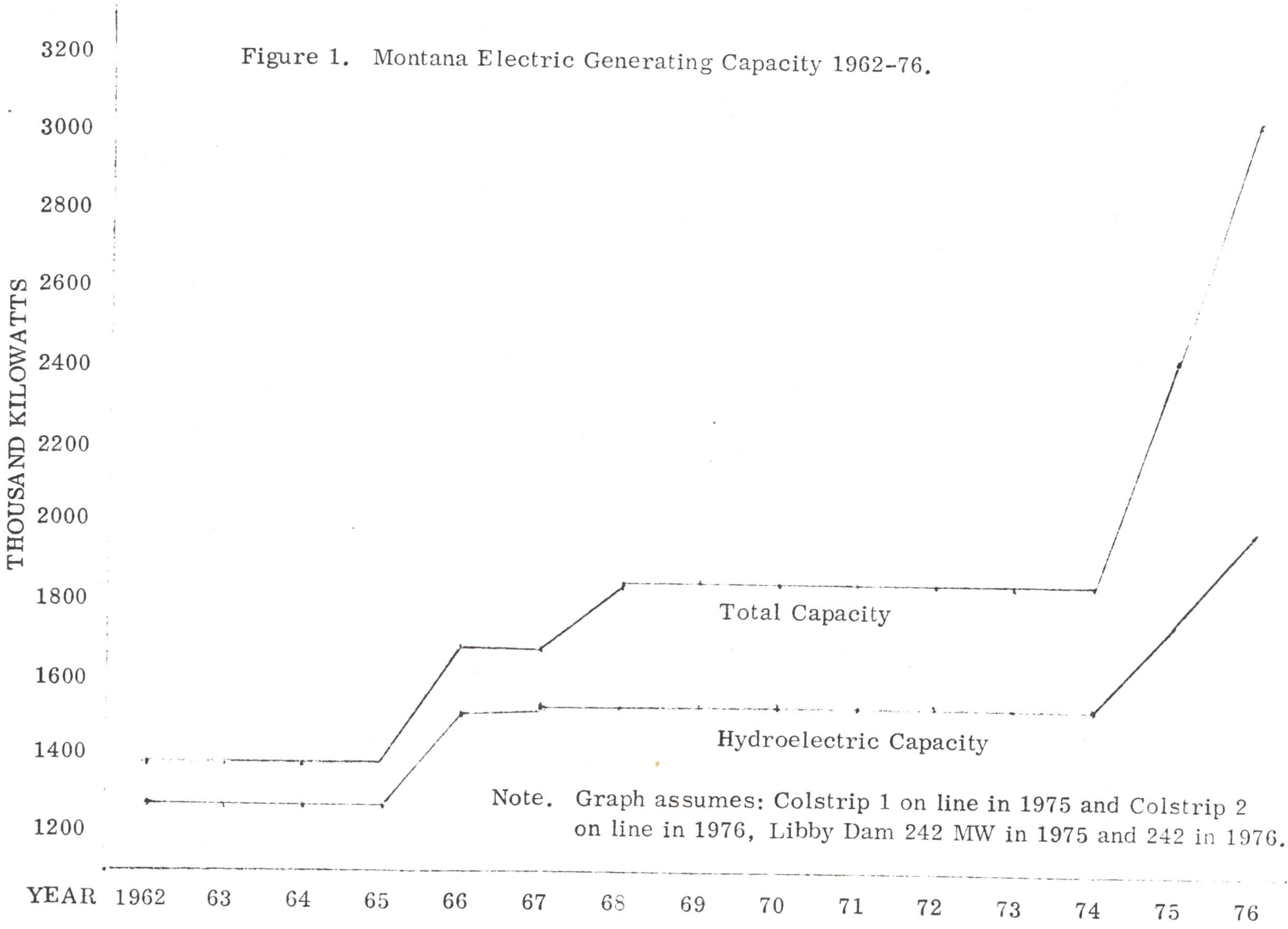
Historically, most electricity generated in Montana has been consumed by a small number of energy-intensive industries. These companies consume two-thirds of all electricity sold in the state. Largest among the industrial consumers is the Anaconda Aluminum Company reduction plant in Columbia Falls, which consumes about a third of all electricity used in the state. Table IV lists other large users.

Industrial users use of electricity is growing at a faster rate than total electricity use in the state. Figure 2 shows that total electric use during the 1950-1972 period grew at 6.38 per cent a year while use in industry grew by 6.8 per cent a year. The Arbiter copper reduction plant, now under construction at Butte by the Anaconda Company, will increase the industrial energy load by 20 megawatts.

Residential use of electricity is increasing due to new home construction, increased use of electric heat in rural areas and air conditioning in all areas, and increased pump irrigation by farmers. The sales of electricity by class of customer are shown in Table V.

As Table VI shows, the Northwest is the only region in the country where summer peak loads are consistently less than December peak loads. Northwest utilities need power to satisfy high residential and commercial demands of winter. Southwest and South-Central U.S. utilities experience their peaks in summer because of the great demand of air conditioning systems. It would seem that with cross-country interconnection, fewer new generating facilities would be needed in the Northwest if it could share loads with the Southwest or South-Central states.

Figure 1. Montana Electric Generating Capacity 1962-76.



Note. Graph assumes: Colstrip 1 on line in 1975 and Colstrip 2 on line in 1976, Libby Dam 242 MW in 1975 and 242 in 1976.

Table I

Consumption of Energy in
Electric Generation
Montana 1971

	Trillion B.T.U.
Coal	17.4
Petroleum	0
Natural Gas	1.1
Hydropower	98.3
Nuclear	0
TOTAL	116.8

Source: Dupree and West. Bureau of Mines. N. Great Plains Resources Program. "National and Regional Energy Considerations."

Table II

Proposed Electric Generating Plants

Coal Fired

Owner	Name	MW Capacity	On-line Date
MPC et. al.	Colstrip III	700	7/78
MPC et. al.	Colstrip IV	700	7/79
Unassigned		500	by 1982

Hydroelectric

Agency	Name	MW Capacity	River
Public	Long Meadows	9	Yaak
Public	Kootenai Falls	360	Kootenai
Public	Libby Rereg	44	Kootenai
Private	Buffalo 2	120	Clark Fork
Public	Buffalo 4	120	Clark Fork
Public	Quinn Springs	108	Clark Fork
Public	Quartz Creek	104	Clark Fork
Public	Knowles	512	Flathead
Public	Smoky Range	330	Flathead N. Fk.
Public	Spruce Park	380	Flathead M. Fk.
Public	Ninemile Prairie	92	Blackfoot
Public	Allenspur	250	Yellowstone

Source: 1970 National Power Survey, Federal Power Comm.

Table III

Major Montana Generating Stations

Name of Plant	MW Capacity	Type	Ownership
Canyon Ferry	50.0	Hydro	Bureau of Rec.
Cochrane	48.8	Hydro	Montana Power
Fort Peck	165.0	Hydro	Corps of Engineers
Frank Bird[1]	69.0	Steam (oil or gas)	Montana Power
Frank M. Kerr	168.0	Hydro	Montana Power
Hungry Horse	285.0	Hydro	Bureau of Rec.
Morony	45.0	Hydro	Montana Power
Noxon Rapids	282.9	Hydro	Wash. Water Power Co.
Ryan	48.0	Hydro	Montana Power
Yellowtail	250.0	Hydro	Bureau of Rec.
Lewis and Clark	50.0	Steam	Montana-Dakota Utilities
J. E. Corette	172.8	Steam (coal-fired)	Montana Power
		Under Construction	
Libby	420.0	Hydro	Corps of Engineers
Colstrip 1	360.0	Steam (coal-fired)	Montana Power/Puget Sound Power & Light
Colstrip 2	360.0	Steam (coal-fired)	Montana Power/Puget Sound Power & Light

[1] Only occasionally operating due to high fuel cost.

Source: Federal Power Comm., "Principal Electric Facilities Northwestern Region."

Figure 2. Sales of Electricity in Montana.

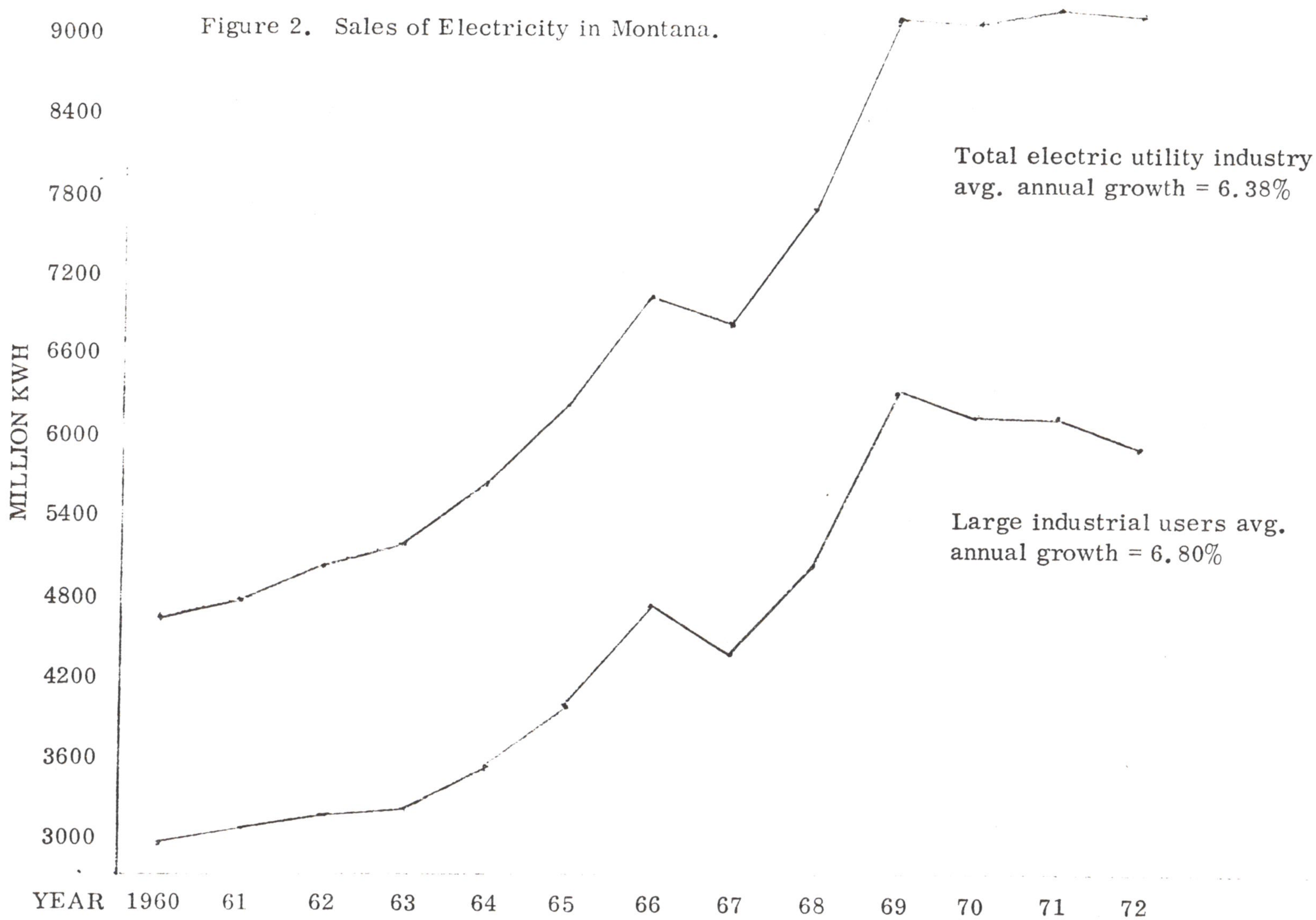


Table V

Sales of Electricity in Montana 1971

Class of Service	Million KWH	Percent
Residential	1614	.17
Small Commercial and Industrial	1254	.13
Large Commercial and Industrial	6079	.66
Service and Highway Lighting	53	under .1
Other Public Authorities	113	.1
Railroads	80	under .1
Interdepartmental	21	under .1
TOTAL	9214	

Source: Edison Electric Institute 1971 Energe Sales--
Total Electric Utility Industry.

TABLE VI

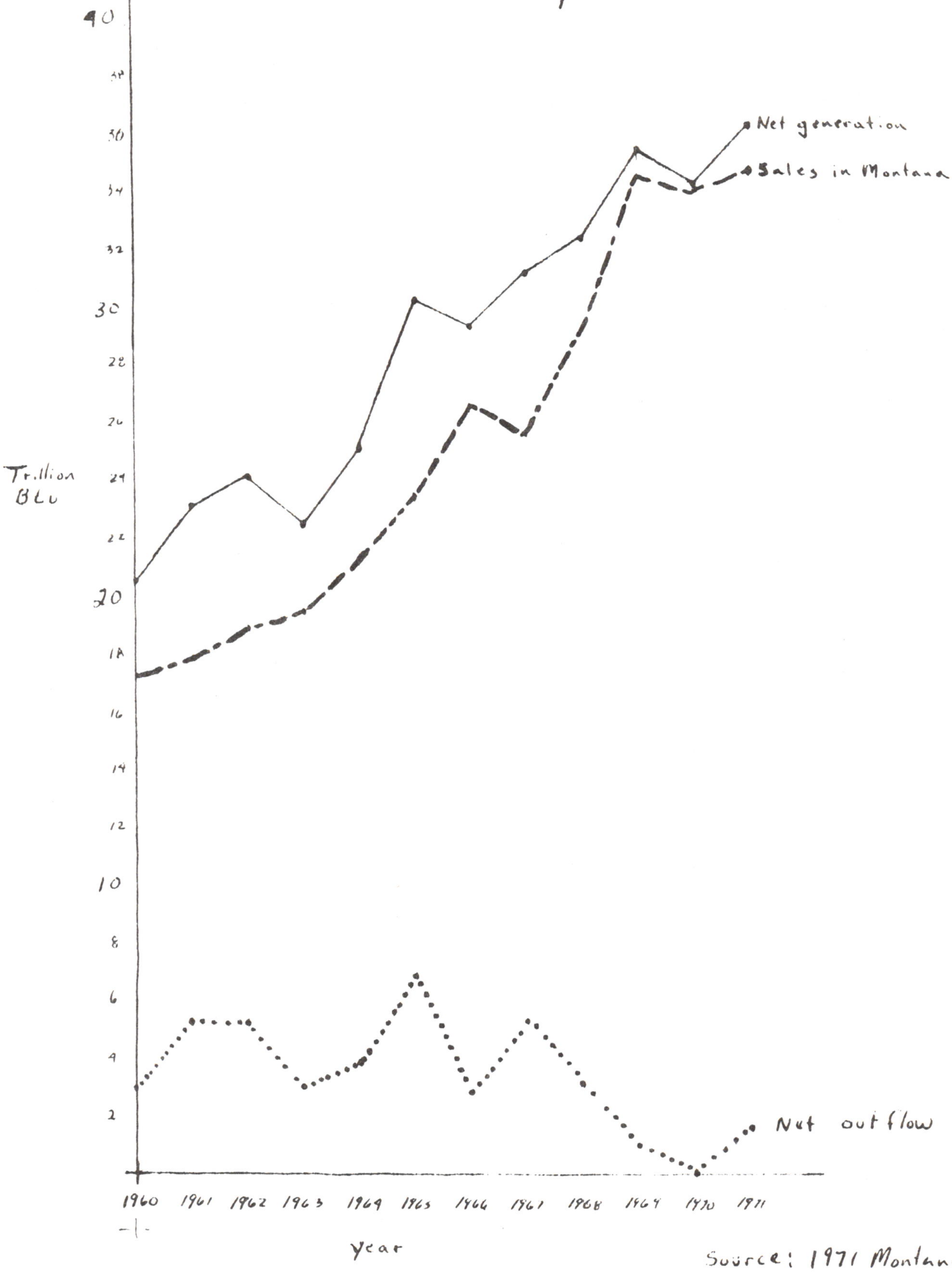
Summer Peak Loads Expressed as Percentage of
Peak Load for the Following December

Area	1968	1969	1970	1971	1972	1978 Forecast
Northwest	72	81	82	77	73	80
Southwest	99	105	102	104	101	108
South Central	143	151	153	146	143	146

Source: Edison Electric Institute 53rd Semi-Annual Electric Power Survey.

Figure 2

Montana Electricity



Source: 1971 Montana Data Book

CONSERVATION OF ELECTRICITY

Rate Restructure

Significant electricity conservation could begin with a restructuring of rates.

The bulk user of electricity pays less per kilowatt-hour than other consumers. Historically, this rate structure has encouraged consumption of essentially surplus energy, but this practice also encouraged wasteful and even profligate energy use. Today there is no surplus of power; the utilities in the Northwest have problems meeting electricity demands now, and forecasts for shortage are coming. For this reason, rates that encourage low-cost electricity seem unwise.

Rate restructure of various fuels has been advocated to encourage industry and commercial establishments to conserve fuel. Rate restructuring assumes that the costlier the energy, the more conservatively industry will be in using it. This, of course, depends upon what economists call the price-elasticity of the demand. Some increase in the price of gas, electricity, and oil will be inevitable because of the scarcity of fuels and inflation. If the price increases much faster than real income, there may be a dampening effect on demand. If the price of electricity increases slower than income increases, there may be increased demand.

Montana's existing rate structure for electricity is based on the premise of decreasing marginal costs. As more electricity is sold, this premise holds, the average cost per kilowatt-hour of maintaining the power plant is decreased.

The premise and its conclusion are no longer valid, however. Because of higher costs for labor, capital goods, scarce resources, interest rates and environmental protection, new power plants are becoming increasingly more expensive to build. The Montana Power Co. estimates that costs have doubled in six years. Since most hydro-electric dam sites are occupied, the company has chosen to build coal-fired plants, which are much more expensive to build and maintain than hydro-electric units, to meet future power demands. Consumers are not getting the appropriate economic signals when they are charged less for using additional energy even though costs for the additional capacity to meet the demand are greater than costs for existing capacity.

The existing rate structure also fails to reflect the consumer's contribution to the peak load. Plant capacity, transmission and distribution networks must all be adequate to meet the peak demand. Therefore, it seems reasonable to change proportionately larger amounts for electricity delivered during the peaks. But most electric rates today are the same during peak and off-peak periods. This practice tends to give consumers the impression that using more power reduces their long-run average costs. Actually, it has the opposite effect because the additional (expensive) capacity must be built to meet the increasing demand. A utility's long-run cost of service and rate per kilowatt-hour is largely determined by capital cost. It is important therefore to relate periods of peak demand to additional costs of meeting those demands and to reflect this relationship in the rate structure. Table I shows the three main classes of customers and the rates charged them.

TABLE I* - CUSTOMERS AND RATES (1972)

Class	Average Charges (cents/kwh)	Consumption of total electricity sold (per cent)	Contribution to total revenue (per cent)
Residential	2.25	20.1	36.5
Commercial	2.03	17.4	28.4
Industrial	0.75	46.1	27.8

*Source: Montana Public Interest Research Group (MONTPIRG)

Montana should study whether current rate structures are reasonable and fair. Not only the amount consumed, but also the time of consumption should be considered. If cost to the customer were higher during peak demand periods, some of the demand might shift to off-peak periods, improving the system load factor balance because it is more efficient to supply a steady demand than it is to recomodate a fluctuating one that has high peaks but generally low demand.

The possible economic impacts of alternative rate structure should be analyzed thoroughly to avoid economic disruption. For example, if the cost of Montana electricity were to become too high, goods produced in Montana might not be as competitive. Industry might relocate, depending on the amount of electricity required, the degree to which efficient machines, human labor and fossil fuels could replace electricity, the extent to which the industry competes with out-of-state firms, and its dependency on Montana resources. Of course, at least a portion of any increasing cost is ultimately passed along to the consumer.

Electricity Conservation Suggestions

Insulating the Great Indoors

Montana utilities might look into sponsoring low-cost loand for added insulation for its all-electric residential customers.

"Waste heat" from electricity production, usually in the form of steam and hot water, does not have to be wasted. Steam can be sold for industrial use or for heating and cooling of residential and commercial districts. At Colstrip, some of the waste heat from the power plant could be used to heat the town. Some of the heated water could be used in sewage treatment. Heated commercial greenhouses can raise food year 'round.

Another very promising use for waste heat from power plants is aquaculture. Areas of the Pacific coast near power plants are supporting man-made colonies of oysters, which bathe in hot water discharges from the plants. In California, algae is grown on the combination of heated power plant effluent and sewage, resulting in an inexpensive source of nutritious animal feed. The sales of the algae for feed pays for the sewage treatment. Algae, or single cell protein, also can be used for human food, although it has a green taste. It is possible, however, to flavor and texturize the product to make it more palatible. The possibility of growing livestock feed using heated power plant water in Montana should be investigated.

A project sponsored by Portland General Electric Company, Pacific Power and Light Company, Boeing Company, and Eugene Water and Electric Board is investigating the use of waste heat from power plants and possibilities for upgrading the energy to usable levels (e.g., the steam-bleed-off-system and heat pump system).

The Aluminum Company of America is testing a system using waste heat from power plant stacks to purify water.

Research and development

The following areas need further research:

A. Conversion technology

1. Energy storage systems utilizing phase-change materials, batteries, capacitors, pumped storage, flywheels, compressed gas, hydrogen.
2. More efficient power generation equipment. (Topping cycles such as gas turbines, magnetohydrodynamics, supercritical and potassium vapor systems; bottoming cycles using ammonia vapor for converting rejected heat into useful energy; fuel cells.)
3. Solar energy systems for power generation. Specific research on photovoltaic cells, properties and radiation stability of plastics, high temperature characteristics of selective optical coatings for solar energy converters, reduction of price and increase of reliability of solar converters.

B. Transmission

1. High-capacity, long-distance underground transmissions.
2. Niobium-plated copper pipe for superconduction.
3. High-voltage direct current and cryogenic cable systems.
4. Ultra-high voltage alternating current systems.
5. High-voltage direct current transmission.

C. Generation

1. Development of materials to withstanding high temperatures and pressures.
2. Improved nuclear plant safety.
3. Geothermal, solar, wind generation systems.

Putting surcharge on peak power use

This could be effective in conservation if the difference in non-peak and peak prices were significant. There would be an expense in changing electricity meters.

Looking to the future

Montana does not and cannot depend on hydro-electric power for all its electricity. As the power demands grow, hydropower will probably be reserved for peaking.

GEOTHERMAL ENERGY

Geothermal means literally "earth heat." This heat results from the slow decay of radioactive elements and from frictional forces. With our present technology drilling depths of 7.5 kilometers have been achieved and someday may reach two or three times that depth. However, the depths from which we may economically extract the earth's heat seems unlikely to exceed 10 kilometers.[1]

The average amount of heat which flows to the surface is very small and would have to be concentrated considerably to be considered as an energy source. There are, however, areas in which molten rock is, or has been, much closer to the surface. It is the areas in which natural heat is concentrated close to the surface that economic exploitation may be possible. In this context, geothermal heat is similar to minerals or petroleum in that it becomes economically exploitable when found in sufficient concentrations.

Geothermal Energy in Montana

A potential geothermal energy site was discovered near Marysville in 1966 by Professor David Blackwell (Geology Department, Southern Methodist University) while he was conducting heat flow surveys in the Rockies. The area has one of the highest geothermal gradients on the continent. Battelle Pacific Northwest laboratories is conducting a three year study on the area under National Science Foundation funding. Another high heat gradient has been found at Butte. In addition, there are a number of hot springs in western Montana and hot groundwater is found in some eastern Montana wells.

A 12,763 acre area in Montana near Yellowstone Park is classified as a known geothermal resource area.[2] More than 3.8 million additional acres are classified as prospective geothermal sites.[3]

Montana has the basic requirements for geothermal energy.[4] Much of the state has evidence of tertiary volcanic instrusive activity. The western part of the state is faulted, the mountains in that area are fault block mountains and the state has high volume aquifers.

The following are potential geothermal areas:[5]

1. Upper Yellowstone River Valley-this area has thermal springs. Some (e.g.Chico) have been used for recreation facilities. Hot water escapes through faults probably from Tertiary intrusive body in the Beartooth Mountains or perhaps from volcanic activity in the Crazy Mountains.

2. Mocassin-Judith Mountain Area-Big Warm Springs a large thermal spring is on the north side of South Mocassin Mountains. Geothermally heated water comes through faults in the loccolithic Tertiary intrusions of the area.

3. Little Rocky Mountain Area-This area has several warm springs coming out of limestone of faults from Tertiary instrusive masses which comprise the core of the mountains.

4. White Sulphur Springs area-A major fault is thought to be under the city of White Sulphur Springs and might be the pathway for heat from Castle Mountain instrusive body or other nearby cooling body.

5. Boulder Batholith Area-Several thermal springs surface along fault lines in this area.

6. Idaho Batholith Area-The eastern part of this area lies in Montana and is a source of dry geothermal heat.

7. Beaverhead Area-This area, south of the Boulder and Idaho batholiths has thermal springs. Drilling for uranium has revealed warm water beneath Big Hole Valley.

8. Snowcrest-Gravelly Range Area-This area west of Yellowstone Park has a heat source probably from deep igneaous instrusions.

9. Madison Group Area-Hot water wells.

GEOTHERMAL SYSTEMS

Different geothermal areas vary according to geological and hydrological characteristics present at each site. The type of system present determines the type of extraction and production techniques, and to a lesser degree the type of exploration methods which are used in the development of the field. The system variation is based largely upon the method in which heat energy is transferred at exploitable depths.

A. Dry Rock Systems

Conduction is the dominant means of heat transfer through solids and therefore the earth's crust. In a largely dry rock conduction system, temperature generally increases continously with depth to the interface of the Moho. Differences in heat flowing through dry rock in various areas of the world arise as a function of the depth of the heat source, the thermal conductivity of the crustal rock, and the thermal gradient. At present there are no dry hot rock systems being exploited, although the technology is currently being developed, as will be discussed later.

B. Fluid Systems

Convection is the other primary heat transfer mode present in the earth's crust. This occurs when fluids are heated and rise as a result of thermal expansion and lower specific gravity. Cooling fluids or cooler ground waters replenish the cycle of circulation which is driven by heat furnished at the base of the system. In a convection system the temperatures tend to be greater in the upper portions than in the lower parts due to the nature of the system. There are two basic typesof water convection systems which differ according to the physical state of the water.

1. Hot Water Systems

Hot water systems are characterized by water in the liquid state, although it may be at pressures greater than hydrostatic. In a major convection system water serves as the medium by which heat is transferred as it moves from a relatively deep geothermal heat source to the surface or near surface. Cool ground waters seep into the perimeters of the geothermal system due to their higher density in relation to warmer heated water. The pressure exerted by cooler waters on less dense heated waters may result in artesian hot springs. If the aquifer, a porous water carrying layer of rock, which lies on top of the heat source is covered by an impermeable caprock, the water may be at temperatures which exceed boiling at atmospheric pressure. This liquid water, under high pressure, may partially flash to steam once the pressure is released either by drilling or by natural faulting in the caprock layer. All of the water does not flash to steam, and thus droplets are carried up with the steam, this is often called a "wet steam" system.

2. Vapor Dominated Systems

A few per cent of the worlds geothermal resources are to be found in the form of vapor dominated systems. At present the only large known systems of this type are found at the Geysers field in California and the Lardello field in Italy. Since they produce superheated steam with no associated liquid, they are often called "dry steam" systems. This steam is generally thought to originate from boiling water in a deep geothermal reservoir with a high temperature heat source and a low water recharge rate. The water reservoir has overlying rock which is highly porous and permible and allows the steam to exist as the continuous pressure controlling phase with pressures below hydrostatic. As the steam rises in the geothermal system it loses its heat to surrounding rock and eventually condenses near the surface in most vapor systems. This condensed liquid, if not lost to the surface, drains downward on the perimeter of the system to deeper water saturated rock on the perimeters of the heat source and serves as a recharge source for the system.

Geoexploration

Geophysical exploration for geothermal energy has been largely adapted from standard geophysical practices, although alterations and various inovations have been found necessary to provide for the uniqueness of geothermal resources. Preliminary exploration selection is based upon a number of previously known geologic factors. The presence of geysers, fumaroles, mud volcanoes, or thermal springs are obvious indicators of geothermal activity. Areas with volcanism of late Tertiary or Quaternary age may also indicate possible near surface heat sources, especially if caldera, cones, or volcanic vents are present. Information available from other activities such as deep mining, well drilling for petroleum, etc. may also provide information pertaining to the possible presense of geothermal anomalies.

Drilling

There are two phases of drilling which can occur in the development of a geothermal field, test drilling and field development drilling.

Test wells are located on the basis of preliminary geophysical exploration. These wells provide subsurface geologic data, information as to the physical and chemical characteristics of the geothermal fluid or rock, help define local productive zones, and help determine the extent and productiveness of the field.

Although the drilling of geothermal wells is very similar to petroleum drilling, geothermal fields present some problems not encountered in petroleum fields. The heat and abrasiveness found in geothermal formations are extremely hard on subsurface equipment. This includes drill bits, valves, cements, casing, etc. Much of the conventional equipment will not stand up to the physical characteristics found in geothermal systems.

The future economic development of geothermal systems which have characteristic that prohibit the use of present drilling technology due to physical economical limitations is dependent upon the development of low cost drilling. Presently, the cost of drilling increases very rapidly with depth. Utilization of geothermal energy at depths greater than 3 kilometers is not economic.[6] The development of low cost drilling to depths greater than 3 km would permit much greater utilization of the heat energy stored in the outer 10 km of the earth's crust.

Plutonic or hard metamorphic rock also limit the use of present drilling technology due to extreme wear on subsurface equipment. High temperatures associated with geothermal systems are also very hard on drilling tools. As a result, costs may be prohibitive to development in geothermal systems with these geologic characteristics.

The Los Alamos Scientific Laboratory has recently been developing drills which bore through rock by progressive melting rather than by chipping and abrading. This borer is electrically or automically heated to melt through rock. As it moves, the molten rock hardens and forms an obsidian-like casing which is fused to surrounding rock. There is no debris to remove from the hole and it would not be necessary to install casing as the glass liner serves that purpose. High temperature rock improves the performance of the drill, unlike conventional equipment performance which is impeded by high temperatures.

A two inch prototype has been developed which consists of a molybdenum shell, a tungsten tip, and a graphite heating element which uses a 3 kw power source. Melting rates have been slow, 60 feet per day. However, calculations show that larger drills should have much higher melting rates as well as increased energy consumption efficiency.

Conversion and Use

The type of technology used in the development of any particular geothermal system is determined largely by the type of system present (e.g. vapor-dominated, liquid-dominated, dry hot-rocks), and by the chemical and physical characteristics of the steam, liquid, rock present in that system. In general, increasing technological difficulty is encountered with the development of vapor-dominated systems, liquid-dominated systems, and hot dry-rock systems, respectively.

The technology for the development and exploitation of vapor-dominated systems, and super heated liquid-dominated systems with low chemical content is readily available. However, the technology for the production of power from low enthalpy hot waters and geothermal waters of high chemical content is in a pre-pilot plant stage of development. The technology for the use of hot dry-rock systems is in the early planning and experimental stage.

Power generation from geothermal energy sources differs from fossil and nuclear electrical generation in several aspects. Geothermal plants do not require hotboxes, boilers, or furnaces, or mining of fuels. However, because geothermal steam or water cannot be transported over large distances, geothermal plants are "mine mouth" plants (the generation facilities sited at the location of the geothermal field).

Efficiency of Electrical Generation

Geothermal power production requires a much larger volume of steam than does a fossil or nuclear power plant to produce an equal amount of electricity because of the relatively low temperatures of geothermal steam resulting in low conversion efficiency. The maximum thermal efficiency of an ideal heat engine is:

$$\text{eff.} = \frac{T_1 - T_2}{T_1}$$

where T_1 is the initial temperature in degrees Kelvin and T_2 is the final temperature.[7] Thus, for geothermal generation in the Geysers field in California, where $T_1 = 452.6°K$ and $T_2 = 299.8°K$, the resulting maximum theoretical efficiency is 33.9 per cent.[8] For a fossil fuel plant, where $T_1 = 811°K$ and $T_2 = 311°K$, the maximum theoretical efficiency would be 66.1 per cent. At the Geysers power generation complex, only 14.3 per cent of the heat energy delivered to the turbine is converted to electricity. At Wairakei, New Zealand, the hot water system produces 24 per cent steam and 76 per cent hot water by weight. Of total heat produced, 59 per cent is in the steam while 41 per cent is in the water. Thus the overall efficiency of electrical production from heat produced at the well head is

$$.59 \cdot 14.3 \approx 8 \text{ per cent}$$ [9]

Conventional Use of Energy in Vapor Dominated Systems

At present time, "dry steam" geothermal systems are more easily exploited, in both technological and economic terms, than are "hot water" and "dry rock" geothermal systems. (Although the dry rock system at Marysville looks promising.)

The steam gathering systems of a "dry" steam geothermal field such as Geysers, California, and Lardell, Italy, separate particulate matter from the steam at the wellhead. The steam is then transported to the power generation station via insulated, steel pipes which are usually located above the ground surface. To provide for thermal expansion of steam lines, vertical or horizontal expansion loops are spaced at regular intervals along the steam line.

It is not practicable to transport steam over distances greater than one mile, due to energy loss and high steam pipe equipment costs.[10] Thus, steam transportation limitations define the maximum area from which steam may be delivered to power generation facilities in any geothermal field using "dry" or flashed steam to generate electricity.

Most geothermal power plants are relatively small, usually not exceeding 110 megawatts at any site. Although each station may be relatively small, a geothermal field may produce large amounts of power depending on the size of the field and the number of stations installed.

At the Geysers and Lardell, Italy, conventional low pressure turbine generators are used to generate electricity. Condensing steam turbines which exhaust below atmospheric pressure are used to utilize the energy of the steam over a larger temperature range, thus increasing efficiency. A condenser at the exhaust end of the turbine creates a vacuum which allows the steam to expand over a larger temperature range than would otherwise occur.

In the process of condensing the steam, a great amount of heat is released which must be transferred to the atmosphere or some cooling medium. There are three basic types of cooling methods involved. The first is "dry cooling" which is similar to an automobile radiator. (No water is evaporated into the air and the preformance of the cooling tower is a function of the ambient dry-bulb temperature.)

A wet cooling tower cools the liquid by direct contact with the air and by evaporation. Although wet tower consumes very large amounts of water; they are more efficient and less expensive than dry cooling towers.

The third type of cooling method passes an outside source of water such as a lake or stream, through the condenser, and discharges the heated water back into the reservoir. This is generally the least expensive and most efficient method where sufficient amounts of water are available, but has potential thermal pollution problems.

Condensed geothermal steam may contain boron, amonia, or ether chemicals which render it unsuitable for disposal into surface waters. Such is the case at the Geysers, where wet cooling tower blowdown is delivered back to the steam producer who disposes of it by reinjection into the geothermal system through a nonproducing well.

Use of Energy from Liquid-Dominated Systems

The technology involved in the exploitation of superheated geothermal waters is more complicated than that used in the exploitation "dry"steam systems.

To be used for conventional steam turbine-generator equipment, the fluid must be superheated (to allow an economic portion of the fluid to be flashed to steam under pressure) and not have high concentrations of dissolved solids, such as SiO_2 or $CaCO_3$. The steam flashing process will deposit scale on subsurface and surface equipment if dissolved solid concentration is high.

Superheated geothermal waters are flashed to steam at a pressure to give the highest turbine efficiency and the greatest steam volume production. Wellhead cyclone separators finish the flashing process and separate the steam from the water. "Dry" steam is directed into a steam line connected to a conventional steam turbine-generator powerhouse.

Water separated from the steam can be reinjected into the geothermal formation to help recharge the fluids of the system and slow ground subsistance due to fluid withdrawal, cooled and discharged into surface waters, or flashed to steam at atmospheric pressure with the use of expansion towers and mufflers, producing large amounts of steam.

Any known geothermal systems are not exploitable due to their chemical or physical characteristics. "Wet" steam can destroy a conventional turbine in minutes through the corrosive effects of high speed particles hitting turbine blades. Non-condensable gases reduce turbine efficiency and excess scaling in subsurface and surface equipment can cause damage and result in high maintenance costs. If steam flashing causes scaling in the borehole, restricted steam production may necessitate redrilling the hole.

Heat Exchangers

Most of the worlds hydrothermal systems are of the"hot" water type with low temperatures and/or high mineral content, and cannot be used with conventional steam turbine-generator equipment, but may be usable through use of a heat exchanger which transfers the energy of thermal water another fluid heaving a low boiling point and high pressure at low temperatures (e.g. iso-butane) which is superheated and used to power a turbine. The cooled water is reinjected back into the reservoir to maintain underground pressures, prevent subsistence, and recharge the geothermal system. The exhaust gas is condensed and then fed back into the heat exchangers.

This bifluid cycle has many advantages over the conventional stea turbine-generator system:

1. Geothermal waters are not allowed to flash to steam at any point in the process, preventing scaling on water conduction equipment and thus allowing the use of geothermal waters with high mineral content for power production.

2. Since water is kept at full pressure, contained gases remain in solution and are returned to the reservoir along with dissolved solids without surface water or atmospheric pollution.

3. Utilization of geothermal waters of low enthalpy is possible due to the nature of the secondary fluid used.

Helical Screw Expander

A new system for the use of superheated geothermal steam has been developed by Roger S.Sprankle of Hydrothermal Power Company.[11] Hot water and/or steam is expanded directly in a screw expander which is between a centrifugal type aerodynamic machine (e.g. turbine) and a positive displacement machine (e.g. steam piston engine). It runs at slower speeds than turbines and, as a result, does not have the balance problems which turbines exhibit. The inventor claims that mineral deposition increases efficiency by lapping to rotor-to-rotor, and rotor-to-housing gaps. Excess deposit is continually scraped away and large scars left by solid particles on moving interfaces are filled in with mineral deposits. Although corrosion and erosion are problems, they are less severe than in turbines due to the bulk nature of the expander.

The helical screw expander can use "wet" geothermal steam or superheated water. Other advantages are seen in its high (70%) efficiency and its ability to run over a wide range of power loads at a constant speed.[12] The wide range of power loads permits the power producer to vary generation according to energy demand.

Bladeless Turbines

U.S. Federal Engineering and Manufacturing Inc., of San Diego, California has designed a bladeless turbine which uses "boundary layer drag" (an undesirable effect in aeronautic design) as a source of rotational torque to rotate the turbine shaft.[13]

The bladeless turbine has the advantage of being able to utilize "wet" geothermal steam without damage from particulate or liquid. In addition, due to its simplicity in design and manufacture, it costs appreciably less than that of conventional turbine equipment.

Environmental Impacts

Geothermal energy has environmental advantages over conventional energy sources. It is not a source of air pollution or radiation hazard, or require that large amounts of land be disturbed (other than for transmission lines or pipelines and the plant itself). However, it does have some environmental drawbacks. Effuent can pollute surface and ground water unless fluids are reinjected into deep reservoirs. Potential thermal pollution problems can also be avoided by reinjection. Other potential problems include noise, objectionable gases, visual impact, and subsidence due to fluid withdrawal.[14]

Introduction

Although it's true potential remains speculative, Montana's uranium ore resource may have an important future in the nation's growing nuclear power industry. The state's nuclear role also may include the second major step in the complex nuclear fuel cycle, the enrichment process which is used to concentrate the energy of uranium for nuclear power plant fuel. Uranium enrichment facilities need not be near uranium deposits however; the primary requirement for a nuclear fuel plant is adequate power (about 2,500 megawatts) to drive the enrichment process. Montana, which has coal and therefore potential for large supplies of electric power, is a potential enrichment plant site for this reason alone.

In order to examine Montana's possible contribution to the nation's nuclear industry and the impact such an industry would have on the state, it must be determined first whether there is a potential here for a nuclear industry and what its adverse environmental effects* might be. Montana agencies may have the authority to impose controls and mitigate these problems.

Uranium Mining and Milling

Reserves and Production Potential

The commercial production of uranium in Montana has been very small; the largest ore production recorded was less than 3,000 tons in 1958.

*for the purpose here, environmental effects include social and economic impacts, and hazards to public and worker health, in addition to traditional environmental concerns about land, air, water and the biosphere.

In only two other years, 1960 and 1961, was production large enough to record. Most of Montana uranium has been mined in the Pryor Mountains of Carbon County. There has been no production of uranium in the state since 1966.

Montana does have potentially commercial reserves of uranium, although there are no maps for exact locations. A number of energy industries are actively exploring for uranium, expecially in areas most likely to have uranium deposits--southeastern Montana in the Fort Union coal region and to a lesser extent, mountainous western portions of the state.

> "Production of uranium from Montana deposits remains more potential than actual. Although uranium production in the State is currently dormant, the discovery of commercially more important deposits is a continuing possibility."

Uranium can be found in association with more than 50 mineral types, mostly rare. The main ores are uraninite, found in vein deposits, and secondary mineral deposits which are the weathered remains of uraninite. The vein ores are found in the mountainous areas of Montana, in particular, the northern half of the Boulder batholith just south of Helena in Lewis and Clark and Jefferson Counties. Veined deposits also have been found in Granite, Madison, Mineral, Powell, Sanders, and Silver Bow Counties. The occurance of the secondary minerals, located in sedimentary deposits, are generally in parts of eastern Montana, notably in Carter and Fallon Counties, and southwestern Montana. The uranium deposits in Carter and Fallon Counties are a portion of uranium-bearing lignite (low-grade coal) deposits which underlie much of North and South Dakota. In southwestern Montana there are uranium-bearing lignites, shales and phosphorite deposits.

> "The amount of uranium disseminated in these sedimentary deposits is very small, but if the need were great enough or the improved treatment techniques developed, they could in the aggregate be the source of substantial amounts of uranium."

Mining

Geological formation, drill patterns made by exploration, and leases all help identify possible commercially minable areas, but none gives information about specific location or type of uranium reserves. Because it is more costly to engage in prospective activities than to hold leases, prospecting patterns are a better indicator of a corporation's interest in the area. Based upon the indicators of geologic formations and type of prospective activity, Sidney L. Groff of Montana Bureau of Mines speculates that Montana does have low-grade uranium reserves, which probably will be mined in the future. According to Groff, the state's reserves are probably not as great as those of Wyoming which are extensive and are now mined.

Present Activity

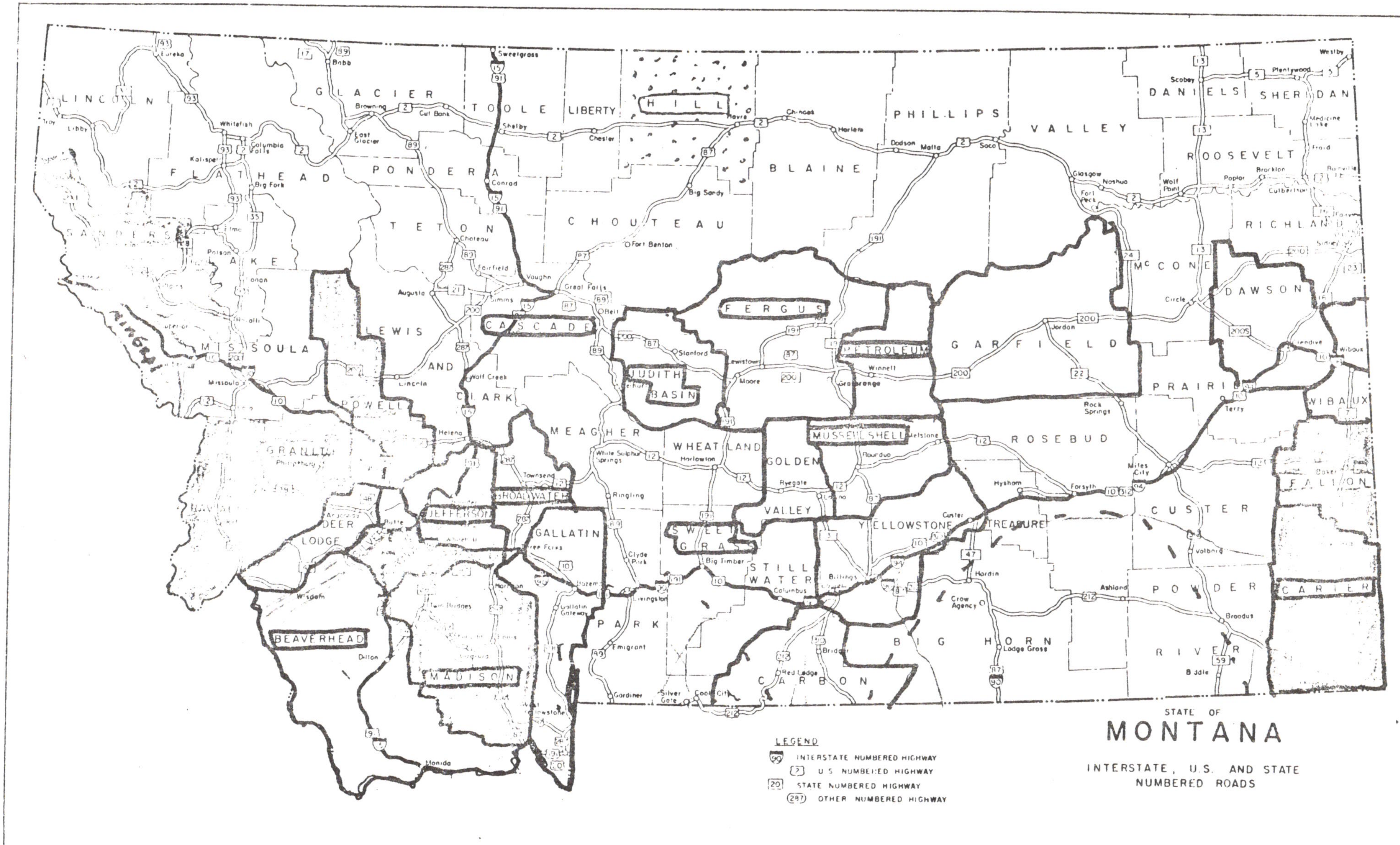
Leasing and prospecting activities show that the uranium industry is interested in Montana uranium reserves. Of more than 85,000 acres of state school lands leased to energy corporations for uranium, about 80 per cent is controlled by two companies, Mobil Oil and Utah International, Inc., in about equal shares. (For county by county listing of total acres leased, see chart.) Prospecting permits are probably a better indication of industry interest in the uranium potential of Montana. The Department of State Lands (DSL) has issued 28 prospecting permits for uranium in 17 counties across the state. These prospecting permits represent 35% of the total permits issued by the Department. (The rest were issued for coal prospecting.) This activity is believed to be mostly speculative exploration to discover marketable deposits of uranium.

URANIUM ACTIVITY IN MONTANA

County	Acres leased on school lands(4/74)	Number of prospecting permits (7/23/74)
Beaverhead	4,490.32	0
Broadwater	2,480.00	1
Carbon	none	1
Carter	14,704.00	7
Cascade	310.00	0
Dawson	none	1
Deer Lodge	none	1
Fallon	none	1
Fergus	11,206.76	1
Golden Valley	none	1
Jefferson	21,000.00	1
Madison	16,608.00	2
Musselshell	1,480.00	5 (1 through State Lands Department and 4 through Bureau of Land Management)
Petroleum	640.00	1
Sweet Grass	480.00	1
Silver Bow	none	1
Wibaux	none	1
Yellowstone	none	1
Total	85,665.00	23 by Department of State Lands 4 by Bureau of Land Management 27 total by state and federal p.p.

Source: Leasing record and prospecting permits issued by Department of Stae Lands.

The geological formations and present uranium industry interest as shown by leasing of state lands and prospecting permits seem to indicate that uranium mining in Montana is a probability. The map shows known geological formations, prospecting permits issued and leases granted for uranium. This map does not give exact reserve location either, but it does show the probable location of uranium in the state. This is not to say that all of these counties have uranium in commercial quantities or will have uranium mining. There are four counties with leasing, prospecting and geological formations known to contain uranium, namely Carter, Beaverhead, Madison, and Jefferson. Uranium mining occurring in the state, of course, will be a function of economics and demand for uranium in the nuclear industry.



- prospecting permits by county; Co. - Leases by county; = deposits by county.

Market Conditions for Uranium

Market conditions dictate whether specific deposits of uranium would be economically mineable. Market conditions for uranium are likely to change substantially in the next few years as the demand for uranium grows. America seems to be counting on nuclear power to solve many of our energy supply problems. The number of nuclear power plants expected to be built by 1980 is eight times the number in operation in 1972. Plant capacity in 1990 is expected to be thirty times that of 1972. Demand for uranium is expected to jump five times by 1980, up from the 8,000 tons a year now consumed. The breeder reactor should greatly reduce the amount of newly mined uranium needed for nuclear plants, but is not expected to be available commercially until mid-1990.

> "Cumulative U.S. requirements for uranium oxide from 1971 through 1985 have been projected at 450,000 tons, with 59,300 tons needed during 1985 alone (Natl. Petroleum Council, 1971 p. 147) Before 1990, total cumulative requirements will exceed the current estimate of our low-cost uranium resources."

Until the advent of the breeder there seems to be no relief for the expected high depletion rate of our domestic uranium reserves. Although low-cost U.S. uranium may be in short supply in the next 20 or 30 years, Canada does have extensive uranium reserves.

> "Current production of uranium is some two-thirds below short-term capability, and less than one-third of Canada's known low-cost reserves are committed. Moreover, large areas of Canada are geologically favorable for uranium, and many are relatively unexplored."

However, the U.S. turned down Canadian uranium contracts lastyear to favor developing domestic reserves. Meanwhile, Canadian uranium prices and markets rose. Now the U.S. is again interested in Canadian uranium, but so are many other countries. Importing uranium from Canada and other free-world nations is still a possibility, but now that energy self-sufficiency is a national goal it may not be wise. If the United States is to be energy self-sufficient or cannot import sufficient ore, it will be necessary to utilize low-grade, formerly uneconomical, uranium ores.

MINING TECHNIQUES

There are three methods used to extract uranium; each of which might be applied to recovery of Montana's reserves. Two of the methods, open pit and underground mining, are conventional. Solution mining is semi-experimental. Open pit mining is used to extract ore which is relatively close to the surface and resembles open pit mining of other minerals. Underground mining is used to recover deep reserves and may be used in conjunction with open pit mining. Solution mining, though somewhat experimental, can recover reserves at underground mining depths. In solution mining, an acidic solution injected through a well leaches the uranium deposits. The uranium-bearing liquid is then pumped from the deposit through production wells to a recovery plant which separated the uranium from the acidic solution. This waste solution is then discarded into tailings ponds. Although solution mining is still basically experimental, it was used in Shirley Basin, Wyoming from 1967 until 1971 when damage to the aquifer was discovered.

A facility generally located near open pit or underground mine sites is the uranium mill. Low-grade ore (mostly 0.1 to 2.0 percent uranium) moves from the mine to the mill where the uranium ore is separated from waste rock. The ore crushed to the consistency of fine sand and mixed with water, is pumped into leaching tanks, where (according to ore type) an acidic or alkaline solution is added to dissolve the uranium. At the end of this process the uranium is called "yellowcake" and contains about .7 percent uranium. The solid waste products (tailings) are suspended in the liquors and then,

> "pumped by slurry to tailing dumps located alongside the mill. The liquor ultimately evaporated or seeps into the ground or is allowed to flow into natural waterways at a controlled rate dictated by applicable regulations. The sand-like material remains and the radioactive daughter products of the uranium remain in the tailing piles."

The amount of tailings from a particular mill depends upon the percent of uranium per ton of ore. The national average ore contains .25 per cent uranium. Only about five pounds of uranium and 100 pounds of vanadium is removed from each ton processed; the balance (nearly 1,900 pounds) is heaped on a tailings pile as waste. If Montana's uranium reserves are of a lower quality than the national average, which is probably the case, waste tailings would be higher than average.

ENVIRONMENTAL EFFECTS

There are environmental problems associated with any open pit or underground mine; here the emphasis will be on environmental impacts specific to uranium mining.

The power of condemnation of surface rights for strip mining of coal has been taken from energy companies, but this option is still open for the strip mining of other minerals. Under current laws, a surface owner can have his land condemned to allow surface mining of the uranium. Because there are social and environmental problems common to all surface mining disturbances, perhaps condemnation powers should be taken from uranium miners too, at lease those who surface mine the metal.

Open pit and underground uranium mining both have problems associated with the disposition of overburden. One problem associated with surface or underground uranium mining is that radioactive material leached from tailings may enter nearby streams.

> "This hazard can be controlled by adequate monitoring, impoundment of water for critical periods, control of discharge, and by suitable design of tailings areas to prevent uncontrolled leaching."

Underground mining poses a unique problem in that there are occupational hazards associated with working in a closed space with radioactive materials. A direct relationship has been established between occurance of lung cancer in underground uranium miners and the level of radioactive by-products in the mine atmosphere.[24] This problem can be alleviated by adequate ventilation and limiting the amount of time workers spend in the mine.

> "The possibility of danger to workers in underground mines and their associated mills due to radon emissions. This danger is one of the industrial or work environment, and it is unlikely that the situation will ever be encountered where there is damage to the natural environment outside the mine itself. The danger can be minimized by adequate ventilation within the mine and by rotation and scheduling the workers to control the time spent in the critical areas. Modern statistics

> of health injury to miners of radioactive ores show that with present understanding and management the awareness of the miners and mill workers themselves, risks from accumulated radiation are negligible in uranium mines today."

Open pit mining does not share this ventilation problem. Although solution mining does not cause the surface disturbances of open pit mining (and therefore seem to be more environmentally attractive) it does pose problems for water quality and aquifers in the mining area. Groundwater quality may be affected by the acids used in solution mining. There needs to be more research to discover and control other adverse effects of solution mining.

Mill tailings from uranium mills and recovery plants are discarded in a slurry to ponds where the liquid must evaporate, seep into the ground or flow into natural waterways.[29] The substance which remains is a sand-like material containing the radioactive byproducts of uranium. If allowed to contaminate surface or groundwater resources, the tailings can contaminate water used for other purposes. Also, as the tailings dry, wind lifts radioactive particles into the air. To prevent water and air pollution from the long-lived radioactive contaminants, it is necessary to isolate the tailings pond from these weathering factors for many years.

<u>Controls on Uranium Mining and Milling</u>

The controls on uranium mining and milling cover two areas: regulation of mining process and regulation of radioactive pollution from uranium reserves and waste. Open pit mining of uranium is regulated by Department of State Lands under the Strip Mine Reclamation Act and required reclamation of disturbed land. Because the present regulations do not specifically apply to uranium mining, new regulations should be promulgated. Underground mining is not controlled except for its surface disturbances. The chief occupational hazards of underground uranium mining are regulated by Department of Health and Environmental Sciences (DHES) under the Radiation Control Act, which can require control devices. Threats to groundwater quality from solution mining can be controlled by the DHES under the Water Quality Act, although other problems may not. The regulations under the Water Quality Act are not promulgated specifically for solution mining.

The environmental effect of uranium mine and mill tailings also is regulated by DHES under the Radiation Control Act. However, existing regulations concerning tailings are inadequate. The regulations were written in 1971 before many new techniques for control of tailings were devised. Perhaps new regulations should include these techniques. The Atomic Energy Commission has regulative powers in the uranium milling process, however, the state can assume its function by becoming a so-called "agreement state." By assuming the AEC's standards, the state then assumes the AEC's regulatory authority. The 1969 legislature authorized the governor to "enter into agreement with the federal government providing for discontinuing the federal government responsibilities with respect to sources of ionizing radiation and the assumption of the state thereof." State regulation might be more strict than AEC regulation. It is estimated that it would require six months of preparation before the state's regulatory program could meet federal standards.

Uranium Enrichment Facilities

A uranium enrichment facility is one of the many processes associated with the nuclear fuel cycle and considered for location in Montana. The uranium enrichment process increases the proportion of fissionable isotope required for fuel in most nuclear power plants. There are only three uranium enrichment facilities operating in the U.S. The process, which increases the uranium -235 isotopic concentration from .7 to more than 2 per cent, is not performed by private industry. However, future uranium enrichment plants probably will be built and operated by private industry. The foreign demand for enriched uranium is increasing at a rapid rate. It is projected that 10 or 11 new plants will be built in the nation by the year 2000, totaling more than three times the present capacity.

Colstrip, Montana and Gillette, Wyoming were considered by a three-company consortium as possible sites for an uranium enrichment plant, mainly because of the large electric power requirements of such a facility. Although these companies have decided to locate elsewhere, Montana remains a prime site for future enrichment facilities due to the state's vast coal reserves with the possibility of mine mouth electrical conversion of these reserves, and the increasing demand for new uranium enrichment plants.

The power requirements of an enrichment plant exceeds the total power output now planned at Colstrip. The enrichment plant itself would require approximately 22,000 acre feet of cooling water annually.[21] The facility also would require 500 to 600 acres of land during its 30 to 40-year operating life to allow waste disposal from the process.[22]

<u>Environmental Impacts</u>

The enrichment facilities pose a two-fold environmental impact. There are social and economic costs and benefits (associated with any large scale industrial development in a rural area) and there are possible problems associated with the disposal of waste from the enrichment process.

Social Impacts

To construct an enrichment plant, it requires three to four times the employment needed for a 2,500 megawatt plant and associated mine. In operation, the enrichment plant needs almost twice the number of employees compared to operating a 2,500 megawatt electrical generation facility. Both the enrichment plant and power facility (with mine) would be near one another; the environmental problems would be, therefore, additive.[31] An enrichment facility would require 500 to 600 acres during its normal 30-to 40-year life span to allow waste disposal.[32] Some of the radioactive by-products, for example, are valuable for other uses and may be temporarily stored in sealed containers on site for later use. Other liquid and solid chemical wastes are treated and diluted for release, burial on site, or to be packaged and shipped elsewhere.[33] Environmental problems can be mitigated to some extent by proper licensing and regulation by either state or federal government.

Uranium Enrichment plants would be regulated by the Department of Natural Resources under the Utility Siting Act and Department of Health and Environmental Science under the Radiation Control Act. Although the location of both the enrichment plant and its coal-fired power plant would be covered under the Utility Siting Act, it is not clear whether the two would be considered together or separately. There are no regulations under the Utility Siting Act pertaining specifically to enrichment plants, but there could be. The Radiation Control Act could control any radioactive pollution from the plant as well as waste disposal and occupational hazards if Montana were an "agreement state." Montana has not gained this status. Until it does, the Atomic Energy Commission has the main regulatory powers with the state Department of Health of maintaining a "watchdog" function over the AEC. The Western Interstate Nuclear Board has contacted the state of Montana over possible assumption of federal regulation by becoming an "agreement state."

SOLID WASTE

Note to reviewers: This section is incomplete at this time. In general, it surveys three potential solid waste energy sources: urban solid waste, wood waste, and agricultural waste. The probability of significant energy uses of solid waste appear low at the present time.

SOLAR ENERGY

"Solar energy is an essentially inexhaustible source potentially capable of meeting a significant portion of the nation's future energy needs with a minimum of adverse environmental consequences ... The indications are that solar energy is the most promising of the unconventional energy sources..."*

Solar energy has the potential of providing an almost unlimited supply of energy, provided we can develop the technology to use it economically. Approximately 2,000 Kwh (or two billion calories) per square meter of solar radiation fall on U.S. deserts annually. Assuming five per cent efficiency of collection and conversion of the sunlight, an 8,000 square mile plot of desert solar-energy-collectors would be required to supply the electrical energy consumption in 1970.

Solar energy is clean, self-sustaining and is the most abundant source of energy on earth. However, it also is difficult to collect and store, using today's technology, it is of low intensity, and it is not dependable. Solar radiation is only available in significant quantities during daylight hours and its intensity varies from hour to hour, day to day, season to season, and place to place on the earth.

Solar radiation is measured in langleys** with an instrument called a pyranometer at two stations in Montana - Great Falls and Glasgow. Montana, on the northern border of the ideal solar belt (the area between latitudes of 15° and 35° north and south of the equator), receives the equivalent of from 114 langleys (in December) to 633 langleys (in July) of solar radiation per day. The average insolation rate is 350 langleys a day.

* Testimony of Dr. A. Eggers of the National Science Foundation before the Senate Interior Committee on June 7, 1972.

** One langley equals one calorie/cm^2 - min. or 3.69 BTU/ft^2 min. or .0698 watt s/cm^2

During the winter when the heating load is greatest, the insolation load is least. However, even during January, the solar energy striking 200m^2 (the size of the roof of a small house) is 1½ times the amount needed to heat a 15,000 BTU/DD*** house. Not all of this energy can be transferred directly into space or water heating because of the conversion losses of solar energy devices.

Conversion Processes

Solar energy conversion processes are classified as heliochemical, helio-electrical, and heliothermal.

The heliochemical process is a process by which the solar radiation is utilized directly by plants (photosynthesis) and indirectly by animals -- a vital process in an agricultural state. Our existance depends upon the photosynthetic process. Plants supply us with food energy as well as an oxygen-rich atmosphere. Plants are also a potential energy source. The heliochemical process is used in some sewage treatment plants. In fact, one pilot plant in California is using solar energy to produce large quantities of algae which is grown on and thereby treats sewage. The algae is then marketed as animal feed.

The helioelectrical process converts solar radiation directly to electricity, utilizing solid state devices such as photovoltaic cells. The application of this technology has been limited because of the high cost and low efficiency of the collector system. (The average efficiency of the solar cells is ten per cent[1]). Also adequate large-scale power storage systems have not been developed. The adoption of large-scale helioelectrical conversion may present land use conflicts (the solar collectors take up a large land area unless the facility is located in an area with no other viable land use options.)

*** British Thermal Units per degree day data based on Great Falls information.

The heliothermal process absorbs incident solar radiation on a surface and utilized the energy in the form of heat. Systems employing this process are further classified as high-temperature or low-temperature systems. High-temperature systems employ a focusing collector that must track the sun and that concentrates the solar energy on a surface located at the focal point of the collector. These systems are in the research and development stage. Low-temperature systems utilize a flat plate collector oriented in an optimum fixed position. To date, systems have been developed for providing hot water, space heating, and air-conditioning.

Hot water systems are the only solar systems sold commercially in the world today. Markets exist primarily in Australia and Israel but are increasing rapidly in other developing counties.

In Australia, a solar hot water system costs about $300 and will provide between 60 per cent and 90 per cent of the hot water needs of a family of our with an efficiency of 40 per cent.[2]

Markets have not developed in the United States in the past because of the low cost of energy.

Space heating systems are not as well developed as water heating systems; however, there are several demonstration projects in the United States and throughout the world.

Air-conditioning systems are in the research and development stage and are still very costly.

Market for Solar Energy

Within 5 years, many scientists believe, solar-powered systems for heating and cooling homes could be commercially available at prices competitive with gas or oil furnaces and electric air conditioners. Still more significant, but farther in the future, may be means of using heat from the sun to generate electricity; experimental solarthermal units have been constructed in several countries, and several groups in the United States are designing systems to take advantage of improved materials and manufacturing techniques. Eventually the direct conversion of solar radiation to electricity by means of photo-voltaic cells or its bioconversion to wood, methane, or other fuels on a large scale may become economically feasible.

Use of solar energy for individual homes in Montana is contingent upon the commercialization of moderate or low cost solar water or space heating devices, the relative cost of competitive energy forms (gas, fuel, oil, electricity), and the amount and reliability of sunshine in Montana. The physics department of Montana State University is studying the feasibility of solar energy for Montana. Much more data (e.g. isolation rates) must be gathered before an accurate assessment of the availability and feasibility of solar energy for Montana can be made.

The market in the United States for solar energy should improve in the near future. Both the cost and the consumption of energy are continuing to increase. There is also increasing environmental pressure for cleaner systems and a greater concern for energy conservation. Moreover, the federal government has significantly increased the research and development budget to improve solar energy technology.

Environmental Impacts

Solar energy does have potential environmental problems. Individual home heating and cooling systems would probably present few problems other than the taking up of space.

Collecting surfaces absorb more sunlight than the earth does, and while this is not likely to alter the local thermal balance in household or other small-scale use, the larger expanse of collecting surface in a central power plant might. Thermal pollution will also be a problem if water-cooled turbines are used -- indeed, more so than with nuclear power plants because solar installations are expected to have even lower thermal efficiencies. If waste heat is returned to the atmosphere, it could help to restore the local thermal balance. The effects of small changes in the thermal balance would depend on the local meterorological conditions, but are expected to be small. The lack of particulate emissions or radiation hazards might allow solarthermal power plants to be built close enough to towns or industrial sites so that their waste heat could be put to use. Finally, like other industrial facilities, large-scale plants would also carry some risk of accidents, with the attendant possibility of leaking heat transfer or storage media into the environment.[3]

WIND ENERGY

Like solar energy, wind energy has the advantages of being nonpolluting and renewable, and the disadvantages of being intermittent, unpredictable, and diffuse.

In view of the planet's decreasing reserves of conventional, non-renewable energy reserves, wind energy and other renewable energy souces should be considered, even though their use might only be as auxiliary energy. Professor Heronemus, professor of civil engineering at the University of Massachusetts, a leading authority on wind power has summed up this position well: "Combination is the answer; the nation can no longer afford to rely solely on one energy source solution (nuclear power plants). We have to explore every possible energy idea." Interest in harnessing wind energy has been slight due to the low cost of other energy. Now, however, because of the rising cost of other forms of energy, the use of wind power is being examined for technical and economic feasibility. The National Aeronautics and Space Administration is developing a rooftop windmill for homes to provide an auxiliary power source.

Some Montana ranchers and farmers have harnessed the wind for mechanical energy. The mechanical engineering department at Montana State University is investigating the technical feasibility of a tracked-vehicle wind energy conversion system operating on the principle of the sailboat. If, after further study, the utilization of wind energy in Montana appears economically and technically feasible, incentives could be given to ranchers and farmers to develop wind systems as auxiliary power sources.

INDUSTRIAL SECTOR

Industry used 42 per cent of U.S. energy in 1969. The principle consumers, accounting for over half the industrial energy use, were primary metal industries, chemical and allied products, petroleum refining and related industries.[1] More than 46 per cent of the industrial energy used was in the form of natural gas, 26 per cent was coal, nearly 17 per cent petroleum, and more than 10 per cent electricity.[2]

Efficiency

All of the industrial sector (except for four industries--tobacco, apparel and other finished fabrics, lumber and wood and printing, publishing and like industries, consuming as a group only 2 per cent of the U.S. industrial energy) has increased energy efficiency in the past 10 years. In other words, there has been a decrease in energy consumed per unit output.[3] The design of electric power generation and chemical plants theoretically incorporate energy effectiveness by considering both initial and operating costs. However, especially in small industries, energy is not considered to be a significant production cost. Sometimes it is less expensive to leak energy than to correct the situation, especially in Montana where both natural gas and electricity have been cheap. However, the use of energy may decrease as the price of energy increases. Already, some Montana industries are conducting studies on energy efficiency conservation.[4]

Energy-Intensive Industries

Because energy has been plentiful and inexpensive in Montana, energy intensive industries have been attracted to the state. This trend cannot continue indefinitely, however. In the future, it will become increasingly important to analyze the energy demand along with the environmental impact of new industries.

These questions need to be considered concerning existing and future industrial development:

What are the major industrial energy consumers and how much energy do they consume?

How does industrial energy use affect the environment?

To what extent do the existing industries provide direct employment and income as well as secondary economic contributions?

How are industries interdependent inenergy use and needs?

What industrial energy policies can be used to minimize economic impact of energy cutbacks?

Industry and the Economy of Montana

Montana's economy has been sluggish. Per capita income fell from 8 per cent above the national average in 1950 to 12 per cent below the national average in 1970.[5] In addition, Montana historically has had relatively high unemployment and a net decrease in population from emigration. One reason for this is Montana's growth industries are primarily export ones: agriculture, mining, forest products, railroads, and tourism. Examination of these industries explains the economic lag.

Table I--Primary Employment in Montana

	Annual Average			Per Cent Change		
	1950	1960	1970	1950-1960	1960-1970	1950-1970
Agriculture	52,800	39,200	34,800	-26	-11	-34
Mining	10,200	7,900	6,600	-23	-16	-35
Manufacturing	18,000	20,600	23,900	14	16	33
Wood Products	5,400	7,400	8,700	37	18	61
Other Manufacturing	12,600	13,200	15,200	5	15	21
Railroads	14,000	9,000	6,600	-36	-27	-53
Federal Government(Civilian)	8,300	9,900	11,900	19	20	43
Total primary employment	103,300	86,600	83,800	-16	- 3	-19

Source: Wood Production in Montana, Maxine Johnson; Montana Business Quarterly Vol. 10, No. 2, Spring 1972

Agriculture

Agricultural employment has declined over the past 20 years from 25 per cent of the labor force in 1950 to about 13 per cent in 1970.[6] One reason for this decline was an increase in output per man-hour from increased use of technology.

More efficient and more mechanized farms have resulted. The number of acres farmed in the U.S. and Montana remained fairly constant the last 30 years as farms became more industrialized. However, the number of farms and farmers decreased.

Table II--Trend in the Size of U.S. Farms (1971

Year	Acreage
1940	161
1960	297
1970	400

Source: Statistical Abstract of the United States (Department of Commerce).

Increasingly, large amounts of energy are needed to plant, grow and harvest Montana crops. In 1969, farms here used 24,940,000 gallons of diesel fuel and 66,060,000 gallons of gasoline.[7] Large amounts of energy also were needed to mine, produce, transport, and spread the 150,579 tons of fertilizer used on Montana farms the same year.[8] A shorage of fertilizer here could have a nationwide impact because Montana is the second largest wheat-producing state.[9]

Another potential energy-related problem facing agriculture is possibility of fuel shortages at planting and harvest time. Although fuel allocation programs have placed a high priority on the use of fuel for agriculture, a delay of even a few days could mean crop losses. Farming is the backbone of Montana's economy (a billion-dollar industry) so local economic disaster and food shortages on a national level could result from a lack of fuel at harvest time. However, Montana uses only oil from domestic and Canadian sources, and agriculture has high priority for fuel deliveries, so a widespread fuel shortage in agriculture is unlikely.

Here is an account of fuel deliveries in 1970:

Fuel	Number of Farms	Amount of Fuel (1,000 gallons)
Gasoline	20,290	19,827
Diesel	12,712	7,471
L.P. Gas	5,168	1,297
Butane	5,168	1,297
Propane	5,168	1,297
Motor oils	20,522	2,858
Piped gas	20,522	2,858
Kerosene	20,522	2,858
Fuel oil	20,522	2,858

Source: C. Meyer, Montana Department of Agriculture

Fuel Consumption by Vehicles on Farms in Montana (1969)

Vehicles	Diesel Fuel (Thousand gallons)	Gasoline (Thousand gallons)
Wheel tractors	20,400	17,900
Crawlers	4,000	760
Trucks	240	23,900
Combines	130	6,400
Autos and Misc.	170	17,100
Total	24,940	66,060

Source: C. Meyer, Montana Department of Agriculture

If prices for grain and livestock remain high, farming probably will remain Montana's leading industry, but employment in agriculture is unlikely to increase. Both the number of farms and the acreage used for agriculture are decreasing. (From Jan. 1, 1970 to Jan. 1, 1974, the number of farms declined by 1,500 and the acreage in farms by 1.7 million.[10])

Manufacturing

Manufacturing industries in Montana are based primarily on processing of raw materials.

The wood-products industry has become increasingly important to the state economy. Between 1970 and 1973, about 1,000 workers were added by the state's lumber and wood products employers, although a nationwide housing slump is reversing this trend. Wood products industries provide about one-third of Montana's manufacturi jobs.

Cutting trees and converting them to lumber does not use much energy, but converting them to plywood or paper does. Continued supplies of natural gas from Canada are said to be vital to expansion plans in the wood-products industry.

The primary metals industry has experienced slight declines in employment because of energy shortages and the closing of the Anaconda zinc and wire mill in Great Falls.[12] The Anaconda Aluminum Plant in Columbia Falls has an interruptible contract with the Bonneville Power Administration and was forced to cut back production and lay off workers because of BPA electricity shortages in 1973. caused by drought and low reservoir levels behind the BPA's Columbia River dams, the shortage rapidly disappeared during the winter of 1973-1974.[13] Employment at Columbia Falls is back to normal, but the primary metals industry remains vulnerable to employment losses from electricity or gas shortages.

Tourism

Fuel shortages and high gasoline prices could have an economic impact on Montana by reducing tourism. There has never been an accurate determination of tourism's contribution to the state's economy, but it is probably substantial. Tourism has encouraged the building of new motels and restaurants--a boon to the construction industry.

Tourists also help support workers in the service sector. Hotels, motels, and restaurants provide about 10 per cent of the jobs in the state,[14] but these are predominantly low-paying.

Blessed with a low population, adequate federal allocations, and nearby sources of petroleum, Montanans have been spared the gas lines and shortages of other Americans. Gas shortages may discourage out-of-state travelers, but travel by state residents may be less affected.

Railroad Employment

Railroad employment has declined over the past 20 years because of increased automation and the shift from steam to diesel engines, but increased rail movement of coal and expanded passenger service may help.

Energy Consumption and Conservation in Specific Industries

Copper Smelting and Refining

The copper smelting process consists of reverberatory furnacing and converting (roasting may precede these steps). The reverberatory furnace can be fueled by oil, gas or pulverized coal. (Coke, a product of coal, was used in older furnaces; electric furnaces are planned for some new smelters. An average fuel requirement for smelting (although it varies widely) is 375 kilowatt-hours of electrical energy and 32,000 cubic feet of natural gas per ton of crude copper.[15] Refining-either by electrolysis or in a final reverbatory furnace--is necessary to remove impurities. One estimate of energy requirements for electrolytic refining is 615 kilowatt-hours of electricity and 4,700 cubic feet of natural gas per ton of refined copper.[16] Expressed in terms of heat energy, copper smelting and refining uses 40.1 million BTU per ton of market copper.[17] (Combining smelting, 33.3 million BTU and refining, 6.8 million BTU.) This is a very rough estimate as there is no typical energy use factor for the copper industry.

With increased pollution control demands on industry, smelting processes are likely to change. Lower smelting costs, improved pollution control and lower energy consumption could result from:

1. bypassing the reverberatory step
2. flash smelting
3. autogenous smelting (with oxygen and enrichment)
4. expansion of the Arbiter process.

Suggested conservation measures for copper include recycling (recycling of coppor scrap uses less energy than producing copper from ore), and use of more efficient equipment. The Anaconda Company, which consumes a large amount of Montana energy, is studying processes which are more energy-efficient than existing ones.[18]

Aluminum

Aluminum production required more electrical energy per ton than any other primary metal. Alumina, its ore, is reduced in a molten bath. The carbon-lined steel reduction cell holds a mixture of ore and a cryolite so that electrical current can produce molten aluminum at a cathode and oxidized carbon at an anode. The aluminum, poured into ingots, is 99.5 per cent pure.

Most of the energy consumed in aluminum reduction is electrical. The amount needed varies, but it averages about 46.7 million BTU per ton (at 3.4 BTU per kilowatt-hour). The total consumption of power and fuel in aluminum production is about 55 million BTU per ton, accounted for by including the reduction process and, among other things, energy-intensive materials used to construct the electrolytic cells.

Once in the marketplace, however, it takes only about 8.5 million BTU per ton to melt down and re-refine aluminum scrap; processing of wrought aluminum consumes 12 million BTU per ton.[19] Recently, the American Aluminum Company announced a method to reduce energy consumption in aluminum refining by 30 per cent. This could have application to the Anaconda Aluminum Company plant in Columbia Falls, which consumes much of the BPA electricity generated in Montana, but the environmental impact associated with the new process should be studied carefully.

Pulp and Paper Industry

A major consumer of electricity and natural gas in Montana is the pulp and paper industry, Hoerner-Waldorf corporation's Missoula paper mill is a prime example. Paper and pulp industries consume 5 per cent of U.S. industrial energy; of this energy, 10 per cent is used for mechanical devices and 90 per cent for heat.[20] The average U.S. efficiency of energy conversion in this industry is about 60 per cent.[21] Suggestions for energy conservation include tax incentives for purchasing new, more efficient equipment or repairing old equipment.

Petroleum Refining

Energy is required to produce the more than 200 different crude oils and the more than 1,000 petroleum products used in our mobile society. The energy used in refining processes varies with each plant (there are more than 100 different refining processes). On the average, it takes 11 BTU of energy to refine every

100 BTU of crude.[22] The major energy sources used in petroleum refining are:

Energy Sources in Oil Refining

Energy Source	Amount used per barrel of crude	Percentage of total energy used in refining process
Natural gas	.26 million cubic feet	38
Refinery gas	.25 million cubic feet	34
Petroleum coke	.003 tons	13
Fuel oil	.01 barrel	10

Source: Patterns of Energy Consumption in the U.S.(Stanford Research Institute)

About 94 per cent of the energy needed to refine oil comes from these fuels to make heat and steam used in the process. The remaining energy is consumed as electricity, which some refineries generate by steam powered turbine-generator systems. Montana refineries buy from utility companies.[23] The turbine-generator method seems to be more energy-efficient because its hot exhaust can be reused, in the distillation process. Utility power plants dump waste heat into rivers or the atmosphere. However, most electricity used in refineries powers air conditioning, space heating lighting and instrumentation systems, and not refining itself.

Agriculture

The latest agricultural census showed nearly 25,000 farms in Montana with an average size of about 2,500 acres (considerably larger than the U.S. average), and covering a total land area of 62,918,253 (almost 70 per cent of the land). Of the total about 1,841,000 acres was irrigated on about 9,000 farms.[24]

Energy use connected with agriculture includes the manufacturing and operation of farm equipment, the manufacturing and application of fertilizers and other chemicals, irrigation, and of course, photosynthesis, which uses solar energy.

Energy was used to manufacture and spread the 150,579 tons of commercial fertilizers used on Montana farms in 1969. Composting with manure, sewage sludge, and food processing wastes is an excellent use of material which would probably otherwise be wasted (perhaps adding to water pollution). Waste treatment to prevent pollution, of course, requires energy. In addition, composting reduces the use of manufactured fertilizers which require large amounts of energy to produce.

Conservation of Energy in Industrial Use

Here are a few of the many ways industrial users of scarce energy supplies could save money and natural resources too:

1. Reschedule work hours, production and other operations to periods of less intense energy demand. Ask the utility for a discount for off-peak energy use. Refrigeration equipment could be started earlier than usual. Set thermostats to save energy in water heating and cooling, insulate pipes.

2. Reduce maximum loads on heating and compressing equipment by modifying the electrical supply. Efficiency in belting and shafting should be reviewed.

3. Use standby generators during critical peak energy use periods (this doesn't save much energy but it relieves a typical stress on overloaded utility systems).

4. Use photosensitive switches and timers to control outdoor security, decorative and convenience lighting.

5. Reduce blower ventilation whenever possible and consider using natural ventilation. Prefer localized, rather than general plant systems.

6. Eliminate unnecessary lights and reduce excessive illumination.

7. Set space heating thermostats to save energy and protect health (too much heat and cold reduces work efficiency and can aggravate illnesses).

8. Maintain equipment on regular schedules and keep things clean enough to spot inefficiencies and leaks.

9. Consider advanced design of plant systems to use waste heat, heat wheels and heat pumps. Capital investments here can frequently be recovered in energy savings in the long run.

10. Insulate your buildings.

RESIDENTIAL SECTOR

During the 1960-1968 period, U.S. residential energy use increased annually almost 5 per cent (compared to a toal energy use increase of about 4.5 per cent).[1] A similar trend of increasing residential energy is found in Montana and is expected to continue.

Twenty per cent of the U.S. total energy and 34 per cent of the U.S. electrical energy is consumed by the residential sector.[2] Space heating and cooling, cooking and refrigeration account for almost 90 per cent of the residential use.[3]

The residential and commercial sectors account for 19.4 percent of the total energy consumed in Montana.[4] According to the Montana Power Co., the average annual use of electricity for individual Montana homes (including cabins and summer homes) is 526 kilowatt-hours.[5] Homes consume 17 to 20 per cent of the total electricity sold in Montana and residential customers comprise 85 per cent of the total number of customers.[6] In 1970, gas sales (including natural, manufactured, mixed and liquid petroleum gas) in the residential sector account for 34 per cent of the total gas sold in Montana;[7] residential customers were more than 85 per cent of the total number of gas customers. (Table II in the total energy section shows that in 1971, 42.3 per cent of the natural gas was sold to household <u>and</u> commercial consumers).

Collectively, consumers could realize a large energy savings if they <u>choose</u> to conserve energy.

> "Consumer education has the greatest potential for impact on the energy conservation needs of the nation. If consumers can be aware of the energy utilization characteristics of the appliances and equipment which they buy, they will consciously seek the more energy efficient items. Furthermore, if consumers become energy-wise in the way in which they operate their appliances and equipment, they can achieve substantial reductions in energy consumption. I would venture to say that the electrical bills for two identical houses, next to each other, but with different families in them can differ by as much as 50 to 100 percent, depending upon the thermostat settings, how many times the children may leave doors or windows open, whether or not kitchen exhaust fans are used,etc. A slight improvement in the efficiency of an air conditioner or an appliance will not make nearly this much difference." *

*Excerpt from an August, 1973 letter from Herbert Bilkey, Asst. Managing Director, Air Conditioning and Refrigeration Institute.

Space Heating is the largest user of residential energy. By 1980, it will account for 2/3 of the total U.S. residential and commercial energy use.[8]

Virtually all Montana homes have some heating equipment. Over two-thirds of the heaters burn utility gas, one-seventh burn fuel oil or kerosene.[9] Fewer than one home out of 25 have electric heat.

Table I--Type of Heating Fuel in Montana Homes (1970)

Fuel	No. of Households	Per Cent
utility gas	151,104	70
fuel oil, kerosene, etc.	29,850	14
coal or coke	4,531	greater than 2
wood	4,113	less than 2
electricity	8,464	less than 4
bottled, tank, or LP gas	18,503	8
other fuel	720	1
none	19	

Source: Detailed Housing Characteristics. (Bureau of Census, Department of Commerce)

Heating Alternatives

Electricity is non-polluting at the point of use, but inefficient in conversion, transmission, and distribution. Electrical resistance heating efficiency is 100 per cent efficient at the end use, but only about 30 per cent efficient overall considering power plant and transmission line losses*.

Gas or oil-burned heating systems have efficiencies of 40 to 80 per cent. Drawbacks include the necessity of cleaning the furnace regularly to maintain high efficiency, and the expense and scarcity of natural gas.

It is possible to build solar heated homes now, but expensive. However, rising gas and electricty costs may make solar energy competitive. Montana solar homes would need backup systems, using conventional fuels, for extended bad weather. Consumers also may object to the higher initial cost of solar equipment. (A tax incentive, however, might make solar homes more attractive.)

*Thirty-three per cent efficiency for conversion in power plants times 91 per cent efficiency in transmission and distribution times 100 per cent end-use efficiency of electrical heating equals 30 per cent total efficiency.

The use of geothermal energy for heating involves many technical problems but at least one rancher in eastern Montana is using hot water from the earth to heat his home.

Most buildings require primarily low-energy heat (space heating requires air temperature 28°C and water heating temperature of 60-65°C, which is less than the temperature of cooling water or steam of power plants). It therefore makes sense to use low-energy heat for such uses (if it is economically and technically feasible) rather than high-energy heat. For example, heat from lighting, air conditioning, and refrigeration can be reclaimed to use for space heating. Hot water or steam from power plants can be used for space heating of whole residential districts.

Supermarkets could use waste heat from their large refrigeration units for space heating during the winter.

The heat pump, another energy-conserving space heating device, has an overall efficiency of 60 per cent (about the same as a gas-fueled furnace) and is not expensive when installed in conjunction with central air conditioning.

Additional space heating conservation measures include tightening up control on FHA insulation standards; formulating insulation standards for state building codes; and allowing tax deductions for home energy conservation measures (planting trees for weather breaks and shade;re-insulating older homes, purchasing storm windows,etc.).

Utility or cooperative extension service consumer tips also are helpful in promoting consumer conservation (e.g. leave thermostat at 70 degrees or lower during day; turn heat down at night; turn heater off during vacations; clean furnace filters periodically; close doors to unused rooms; close damper when chimney not in use; caulk and weather strip cracks; draw curtains).

Water Heating

Water heating is a second major residential energy user. In 1968, 92 per cent of all U.S. households had gas or electric water heaters (only 74 per cent had them in 1960).[11] About 70 per cent of the water heaters were gas, 25 per cent electric.[12]

In Montana, 97 percent of all homes had water heaters in 1970.[13] Over 60 per cent were gas and 30 per cent were electric.[14]

Table II--Water Heaters in Montana Homes (1970)

Fuel	No. of Households	Per Cent
Utility gas	134,503	62
Fuel oil, kerosene, etc.	726	
Coal or coke	124	1
Wood	652	
Electricity	64,323	30
Bottled, tank, or LP gas	10,704	5
Other fuel	145	less than.1
None	6,127	3

Source: Census of Housing (Department of Commerce)

The annual average energy consumption for water heaters has gone up since 1960 for both gas and electric devices, probably due to increasing use of dish washers and automatic washing machines.

Conservation measures for hot water heating include running washers and dryers with full loads only, fixing leaky faucets, showering instead of bathing, using alternative water heating such as solar or geothermal, installing the water heater as near the point of use as possible, insulating hot water pipes, and lowering the water temperature setting.

Space Cooling

Space cooling accounted for about 30 per cent of U.S. residential energy use in 1968, triple their consumption in 1960.[15] Only 40 per cent of residences had space cooling in 1970, so energy consumption for air conditioners will probably continue to rise as the market expands.[16]

Only about one out of every 12 homes (less than 10 per cent) in Montana has air conditioning.[17] Most are electric (see Table III).

Table III--Air Conditioning In Montana Households (1970)

Type	No. of Households	Per Cent
Room Unit	15,049	6
Central System	6,929	2
None	240,753	91

Source: Census of Housing (Department of Commerce)

Montana Power estimated monthly electricity consumption of residential air conditioners:

To estimate kilowatt-hours used in average residential installation:

1. Determine size in kilowatts from listing.
2. Multiply KW by number of hours of potential use by month and locality.

Central		Window Unit	
3 Ton 36,000 BTU/Hr	5.5 KW	6,000 BTU/Hr	0.19 KW
3 Ton 24,000 BTU/Hr	3.5 KW	8,000 BTU/Hr	1.35 KW
1 1/2 Ton 18,000 BTU/Hr	2.6 KW	10,000 BTU/Hr	1.6 KW
		12,000 BTU/Hr	1.85 KW
		15,000 BTU/Hr	2.3 KW

Average Hours of Operation

Area	May	June	July	August	Sept.	Season Total
Billings	40	100	230	240	90	700
Bozeman	--	45	135	140	20	340
Butte	--	40	110	125	15	290
Great Falls	15	65	160	180	45	465
Havre	25	80	175	195	55	530
Helena	10	60	160	170	30	430
Lewistown	5	30	110	160	40	345
Missoula	10	75	165	180	35	465

There are about 1,400 room air conditioner models sold under 52 brand names. Efficiencies of the window units range from 41.7 to 12.2 BTU/watt-hour: thus the least efficient air conditioner consumes 2.6 times as much electricity as the most efficient one, although each achieves the same cooling.[18] The efficiency rating for most central air conditioning systems is about 8.5 BTU/watt-hour, or about 30 per cent more efficient than the best window unit.

The decision to purchase an air conditioner based upon cost often makes a significant difference in the lifetime energy requirements. For example,

> "The least expensive version of an air conditioner will usually require twice as much energy per unit of cooling load (compared to more expensive models) due to reductions in condenser and fan size. Regulations specifying certain minimum efficiency levels could result in perhaps a 40 per cent energy saving over the life of such appliances, with resulting savings in operating costs.[19]"

Here are conservation suggestions for air conditioning:

1. require prominent labeling of efficiency (BTU/watt-hr.) and cooling capacity on all air conditioners sold in Montana.
2. require efficiency and cooling capacity information in advertising.
3. require units comeing into state after 1975 to meet minimum efficiency level and be thermostatically controlled.
4. give tax incentives for planting trees and shrubs for shade around homes.
5. raise thermostat to 78°F.
6. close doors to unused rooms.
7. turn off unnecessary lights (they are like a heater in the room).
8. keep condenser coils on air conditioner clean.
9. improve insulation (see section on heating).

Food Preparation

Seventy per cent of the cooking ranges in the U.S. were gas in 1968; 30 per cent were electric.[20] In Montana, the ranges were 65 per cent electric, 25 per cent gas.[21]

Table IV--Cooking Ranges in Montana (1970)

Fuel	No. of Households	Per cent
Utility gas	54,447	25
Electricity	142,739	66
Bottled, Tank, or LP gas	14,329	7
Fuel Oil, kerosene, etc.	2,862	1
Wood	563	
Coal or coke	895	1
Other fuel	184	
None	1,285	1

Source: Census of Housing (Department of Commerce)

Here is the estimated power consumption for some electric cooking appliances:

Table V--Electricity Consumption of Appliances (1972)

Appliance	Average Wattage	Estimated Use	Consumed Annually
Broiler	1,436	80 min/wk	100 Kwh
Frying pan	1,196	26 min/day	186 Kwh
Hot plate	1,257	12 min/day	90 Kwh
Range	12,207	16 min/day	1,175 Kwh
Roaster	1,333	25 min/day	205 Kwh

Source: Patterns of Energy Consumption in the U.S. (Stanford Research Institute)

Dinner preparation contributes to the daily peak load which occurs around 6:00 p.m. Cooking meals before or after the daily peak period should be encouraged. Other conservation measures include covering pots and pans while cooking, turning the oven or range off slightly before food is done and allowing the food to cook with the remaining heat, thawing frozen foods before cooking and baking other foods while baking main dishes. Microwave ovens, electric fondues, waffle irons, electric fry pans and grills are often more efficient than range or oven cooking. Energy also can be saved by energy-conscious design and construction of ovens.

Refrigerators were found in 96 per cent of U.S. homes in 1968 (almost all were electric)[22], and about 94 per cent of Montana homes in 1970.

Here is the estimated annual electricity consumption for refrigerator units:

Appliance	Average wattage	Per cent of time in operation	Est. Annual Consumption(KWH)
Food freezer (15 cu. ft.)	341	40	1,195
Food freezer (12 cu. ft.)	440	46	1,761
Refrigerator (12 cu. ft.)	241	34	728
Refrigerator (12 cu. ft. frostless)	321	43	1,217
Refrigerator-freezer (14 cu. ft.)	326	40	1,137
Refrigerator-freezer (14 cu. ft. frostless)	615	34	1,829

Source: Edison Electric Institute

Freezer sales in the U.S.increased at an annual rate of 1.7 per cent from 1960 to 1969.[24]

Montana's 1970 census lists 94 per cent of Montana homes with complete kitchen facilities (range or cookstove, installed sink and piped water, mechanical refrigerator) [25] About 50 per cent of Montana households have home food freezers.[26]

Patterns of Energy Consumption In the United States

Patterns of energy consumption in the United States shows the energy consumption of food freezers in kilowatt-hours:

Freezer Type	Average Wattage	Annual Consumption (Kilowatt-hours)
15 Cu. Ft.	341	1,195
15 Cu. Ft.(frostless)	440	1,761
Average		1,478

Conservation measures applying to refrigeration devices follow:

1. require refrigerator labelling of efficiency and wattage.

2. open refrigerator and freezer doors only when necessary; close door immediately

3. use chest-type freezers rather than refrigerator type because they lose less cold air when opened.

4. buy refrigerator without automatic defrosting and automatic ice cube maker.

It is estimated that 40 per cent of all U.S. households had clothes dryers in 1969.[26] Two-thirds of the dryers were electric and one third were gas.[27]

About 55 per cent of Montana households have clothes dryers; 94 per cent of them electric.[28]

Conservation measures include the following:

1. require labelling of energy efficiency
2. use clothes line when possible
3. dry only full loads

Dishwashers were found in 20 per cent of U.S. homes in 1969.[29] Twenty-three per cent of Montana homes had dishwashers in 1970.[30]

Energy conservation for dishwashers includes labelling of energy efficiency, washing only full loads of dishes, using proper detergent.

Ninety per cent of U.S. households have at least one television set.[31] Thirty per cent of the homes have color sets, which use 30 to 40 per cent more energy than black and white sets.[32] The U.S. energy consumption in 1968 to energize television was 352 trillion BTU. More than 90 per cent of Montana households have at least one television set.[33]

Conservation measures include using black and white televisions instead of color sets and turning off the set when it is not in use.

Lighting consumes 24 per cent of all U.S. electricity sold and accounts for 1.5 per cent of national energy consumption.[34]

Suggested conservation measures:

1. change current design philosophy which maintains uniformly high light levels, to a conservative approach directing most light to the work area. This measure may reduce lighting energy consumption by 50 per cent.
2. design building to make better use of natural lighting and to allow for optional use of artificial light; use minimum lighting necessary for work.
3. use more fluorescent lights which are three to five times more efficient than incandescent bulbs based on bare bulb comparisons.[35]
4. choose lighting fixtures and locations carefully.
5. turn lights off whenever possible

Incorporating an energy consumption awareness into building design could do much to conserve energy. Listed below are several building design conservation ideals:

1. Area to volume ratio-Geodesic dome

   A house with smallest exposed surface compared to its volume, loses the least heat during winter and requires the least cooling during summer. For the same floor area, two story houses are about 25 per cent more efficient than one story.

2. Building shape-Mandan Lodge

   A round building has less surface area and therefore less heat gain or loss than any other shape with same floor area; a square building has less surface are than a rectangular one.

3. Shape and orientation relative to path of sun

   a. Minimize amount of sunlight on south and west walls and windows

   b. A rectangular building with short axis north and south has less solar heat gain in summer.

   c. Increase reflectivity of surfaces exposed to sun

4. Shade windows from direct sunlight by awnings, overhanging eaves, porches.

5. Insulation requires initial cost but saves fuel for heating and cooling over the long run.

6. Use two layers of heat-absorbing glass (separated by circulating air gap) for windows exposed to sunlight to reradiate as much as 45 per cent of the solar heat.

7. Solar Homes

   a. Solar water heating would be good during sunny weather. But an an auxilliary system is also needed in Montana for periods of unfavorable weather

   b. Solar space heating works even in Boston and New York, where winters are cloudy. Solar space heating reduces other fuel consumption used for space heating.

   c. There is a need for an incentive for builders to incorporate solar features into homes.

8. Ventilation improvements

   a. Use natural air circulation

   b. Use exhausted air from buildings in winter to melt snow on sidewalks, driveways, and ramps by circulating exhaust warm air through tiles under outdoor surface.

9. Use low energy or recycle material like Envirite, stone and wood instead of high energy materials such as aluminum and brick.

COMMERICAL SECTOR

Commercial users consume 15 per cent of the total U.S. energy budget; over 50 per cent of this energy is for space heating and cooling[1] Commercial lighting alone comsumes 1/10 of the U.S. electricity.[2]

In Montana, the commercial sector consumes 14 per cent of the total Montana electricity.[3] It is difficult to determine the total commercial energy consumption in Montana because residential and industrial customers are often included with commercial listings on energy sales figures.

Commercial energy use and efficiency patterns are also difficult to describe because this sector includes so many different types of establishments. Conservation suggestions, however, may include the following:

1. <u>Building design and construction (offices, stores, etc</u>.)

   Designers could save energy and money by careful design using less building material to meet safety standards. Design also should include insulation, using adjustable windows for natural ventilation, orienting the building according to sun and climate factors, using trees and shrubs to cut down on summer sun and winter wind effects, installing efficient heating and cooling equipment, redesigning lighting standards (directing the light to work areas rather than having a uniformly high light level throughout the building), using less glass or using mirrored glass, and using less steel and other energy-intensive materials for construction.

2. <u>Building Maintenance</u>

   There are several energy conservation opportunities in this area: opening windows and doors for natural ventilation, reducing air conditioning (most restaurants, for example, are too cold during the summer due to excessive air conditioning), burning refuse for heat, using heat of lighting systems, heat wheels, heat pumps, and other total energy systems.

3. Outdoor electrical advertising

Energy would be saved by eliminating electrical advertising after business hours or destricting on the maount of energy consumed for advertising purposes.

4. Business hours

Many businesses (especially grocery stores) stay open late at night. During an electricity shortage business hours could be curtailed. However, the financial repercussions of such curtailment must be considered.

TRANSPORTATION SECTOR

Transporting people and freight consumes one fourth of the total U.S. energy.[1] Including secondary transport activities such as fuel refining and manufacturing transportation equipment transportation energy accounts for more than a third of national energy consumption.[2] Since 1950 there has been a 40 per cent increase in per capita energy consumption for transportation and, since 1960, the total U.S. consumption for transportation has increased 52 per cent.[3] People are used to being transported ever faster, more conveniently and comfortably, all at the expense of efficiency.

Efficiency

During the past decade, there has been a decrease in overall transportation efficiency (as measured in BTU per ton-mile), primarily because of shift from waterway and railroad to airplane and truck transportation of freight, the shift from buses and trains to automobiles to airplanes for passenger inter-city travel, and the shift from mass transit systems to private automobiles for passenger inter-city travel. The following tables from Eric Hirst's report show the comparison of efficiencies in transportation[4] (taking into account load factors):

Table I -- Freight-Inter-City

Mode	Btu/ton miles
pipeline	450
waterway	680
railroad	670
truck	2,800
airplane	42,000

Table II -- Passenger-Inter-City

Mode	Btu/passenger-mile
bus	1,600
railroad	2,900
automobile	3,400
airplane	8,400

Table III -- Passenger-Intra -City

Mode	Btu/passenger miles
bicycling	200
walking	300
bus	3,800
automobile	8,100

The most efficient freight transportation modes thus are pipeline, waterway or railroad. The least efficient modes are being used, however, because of the greater speed and flexibility of truck and air freight. The faster, more convenient automobile and airplane are used primarily for inter-city travel rather than the more energy-efficient modes such as trains and buses. For intra-city travel, automobiles are preferred over more efficient modes such as mass transit, walking or bicycling. To add to the problem, the average number of passengers per vehicle is low: (2.4 per car for inter-city travel, 1.4 for intra-city travel and 1.2 during rush hour).[5]

U.S. Transportation Fuel Consumption by End Use Sector and Fuel

The leading U.S. transportation fuel consumers are automobiles which consume 55 per cent of the transportation energy; trucks, 21 per cent; and aircraft, 7.5 per cent.[6] Including energy uses such as manufacture of automobiles, and production of gasoline tires, and oil, the energy consumption connected with the automobile industry is 21 per cent of the U.S. energy budget.[7]

Petroleum accounts for 96 per cent of the total U.S. transportation fuel use,[8] which itself accounts for more than half the total U.S. petroleum consumption. Current U.S. transportation fuel consumption is 6.8 million barrels per day of gasoline.[9] Electric power accounts for 0.1 per cent of the transportation energy (or .19 per cent if secondary electricity consumption is included).[10]

By 1985, it is projected that autos and aircraft, the less efficient transportation modes, will use 73 per cent of the total U.S. transportation energy. (The total transportation energy consumption itself is also growing). Due to the increasing demand for petroleum products and the dwindling domestic supply, much of our transportation fuel probably will come from foreign sources.

Montana Transportation Energy Consumption

Montana consumed 77.7 trillion BTU for transportation purposes in 1971, most of which was in the form of petroleum products (see Energy Flow section).

The petroleum section discusses Montana transportation energy consumption more fully.

Conservation Suggestions

Perhaps one of the most important measures for transportation energy conservation is increasing citizen awareness. Citizens should be made aware of conservation measures.

1. keep car tuned; be sure tires are properly inflated.
2. slow down (at 50 mph the "average" car uses about 80 per cent less fuel than is used at 75 mph).
3. improve driving habits -- accelerate slowly and drive at consistent speeds.
4. warm up cold engine.
5. don't race the engine.
6. plan daily schedule to include a number of errands in one car trip instead of making many small trips in the car during the day -- don't idle while waiting for a passenger.
7. car pool if possible.
8. replace driving with walking or bicycling for short trips (side benefit of health).
9. use city bus service.
10. don't unnecessarily use air conditioner or fan; accessories lower gas mileage by as much as three miles per gallon in cities and two miles per gallon on open highways.

It is important that citizens participate in transportation planning and development. An example of citizen involvement in the transportation planning process in Montana is the Missoula Bikeway Plan.

During rush hour, the average occupancy of automobiles is only 1.2 persons. This is obviously very inefficient. Car pools are much more efficient. To set a good example, state government should encourage car pools among its employees.

Existing street facilities could be set aside for the exclusive use of buses and car pools during rush hours, but this would depend upon the voluntary participation of drivers. Insurance rate adjustments might serve as car pool incentives.

Decreasing the number of parking facilities (by limiting future development and decreasing the number of existing ones) or placing a surcharge on all-day parking would discourage automobile travel to downtown areas and provide an incentive to take the bus or use car pools. These measures, however, unless carefully done, might shift business from downtown to suburban shopping centers.

The traffic signal systems of Montana cities should be coordinated to reduce inefficient stop and go driving. The cities also should study revisions in transportation plans to encourage efficiency -- (e.g. conversion of two-way streets to one-way, elimination of parking on one side of street, development of special bicycle lanes.)

Bike and pedestrian paths would make it safer and more enjoyable for people to ride bikes or walk, and would reduce energy consumption too. There is a need in most Montana cities for such pathways. Oregon, under its HB 1,700, requires one per cent of state highway funds received by county, city or the commission to be used for the development of city and statewide bike paths. This would be useful in Montana.

One conservation measure defeated during the 1974 legislative session was a proposal to tax new vehicles based on their fuel consumption. The lower the fuel mileage the higher the tax. This would have encouraged consumers to buy on the basis of gas mileage. This measure ignores certain inequities because one person may buy a car with low gasoline mileage, not use it much, and, consequently, consume less gasoline than a person driving a high gas mileage car frequently. If this measure were to be implemented nationwide, U.S. manufacturers should be given time to compete effectively with foreign car manufacturers on the basis of gasoline mileage (to avoid worsening the balance of payments problem).

Increasing gasoline taxes would discourage waste or inefficient use of fuel. It would be fairer than the tax on automobiles because only fuel use would be taxed. The measure's conservation effectiveness is dependent upon the price elasticity of demand for gasoline. One disadvantage is that low income and fixed income persons would suffer proportionally more than the rich.

Most automobiles use less fuel at lower speeds. (at 50 mph a car uses about 20 per cent less than at 70 mph). Montana has a new law for a state-wide speed limit of 55 mph. The lower speed limit involves a trade-off between 1) speed and convenience and 2) gas savings and safety. The increased travelling time and cost for the trucking industry are two disadvantages to this limitation.

Electric vans would be a partial solution to the energy problem if clean and renewable method for generating electricity were used (e.g. solar or geothermal). First, electric vehicles are clean (there is a single pollution source at central power plant, however) and require little maintenance. Second, the engine shuts off when the vehicle is not moving so energy is not used to idle. There are, however, disadvantages. Electric vehicles are slow (30 mph maximum) and need to be recharged often (about every 30-50 miles), and so aren't suitable for inter-city travel. However, using them for Montana postal service, for milk deliveries, and for other intra-city vehicles are sensible possibilities.

The Electric Vehicle News (February 1973) reports that the Cupertino, California U.S. Postal Service uses electric postal vans. It takes about 14 kilowatt hours to power the vehicle for a normal mail route -- about 13 miles.

The vehicles are recharged at night during off-peak electricity consumption times. The cost to run an electric van is less than one-fifth the cost for the conventional quarter-ton truck used for a similar route.

Improved rail service in Montana would encourage greater use of trains, which are far more efficient than automobiles. Railway Magazine reports that in 1971, U.S. railroads bought about half as much fuel as highway diesels (including buses) and carried about 75 per cent more tons of freight per mile.

A reduction of the number of flights, and a corresponding increase in flight distance (eliminating milk-run flights) would fill planes to greater capacity for more efficient transportation. (However, short-haul trips, 250 miles or less, account for only 3.8 per cent of total passenger miles.)

About 50 per cent of the new oil sold to lubricate industrial and automotive engines is disposed of each year. Waste oil can be recycled into lubricating and fuel oils. In 1971 the American Petroleum Institute reported that the capacity of reprocessing plants was half what it was in 1965-66. There are several reasons for this decline:

1. Additives in "high performance" lubricating oils complicate and reduce the efficiency of the re-refining process.
2. Some state laws and military regulations prohibit the use of recycled oil.
3. The Excise Tax Reduction Act of 1965 exempts new lubricated oil used in off-highway vehicles from taxes, but not re-refined oil.

It is possible to use a mixture of recycled and new fuel oil in power plants, but the cost of recycled fuel may exceed the price of new oil and additives in the used oil may cause boiler problems.

Oil recycling probably will not be widespread until the legal, technical and economic restrictions are removed.

Other Conservation Suggestions

Containerized freight and computerized yard and interchange control greatly increase freight movement efficiency and should be encouraged, as should development of new lightweight diesel, stratified charge, gas turbine, Rankine, and starting engines.

With the shortage of petroleum, new fuels such as methane, methanol, propane, and ethanol from coal, hydrogen from nuclear energy (as in a hydrogen fuel economy), and chemically stored hydrogen in magnesium hydride, ammonia and hydrazine have become attractive substitutes. Serious problems with these types of fuel include their bulk, fire and explosion hazards, and toxic combustion products. The Transportation Energy R & D Panel of the Department of Transportation rates ethanol second as an automotive fuel (next to gasoline and related petroleum derivatives). Next are propane, methanol, and liquid methane. The other novel fuels are not so attractive.

VIII. PROJECTED STATE AND NATIONAL ENERGY CONSUMPTION

"It is difficult to make predictions, especially about the future."
-Mark Twain

I. It is important to emphasize the uncertainties inherent in any attempt to forecast anything as complex as energy consumption, which involves economic, political, social, environmental, and technological factors, to name only a few things having influence on the energy outlook. An accurate assessment of future consumption would require identification of the most significant factors affecting consumption, estimation of the future behavior of those factors, and evaluation of the sensitivity of energy consumption to that future behavior. Thus a forecast would have to envision the future performance of such things as GNP and Gross State Production, prices and availability of various energy sources, general price levels, costs and extent of environmental protection measures, business cycles, inflation, rates of energy consumption per person and per unit of production, technological innovations, and so forth. Obviously, expectations about each of these factors are subject to considerable differences of opinion, as are evaluations of the sensitivity of energy consumption to each factor.

It is a fact that in the past, reasonably accurate projections have been made for energy consumption, such as those by electric utilities. But the conditions which allowed projections of historical trends to prove accurate in the past seem to be changing. We appear to be entering a period of transition for energy prices and supplies, for the national economy in terms of future growth and the relationship of inflation and unemployment, and for social and political attitudes about where the country is going and how it should get there.

Rapidly rising energy prices are a new phenomenon, and they are taking place at a time when price increases in other sectors such as food, transportation, housing, and many other areas are creating significant economic instability. Inflation has become a dominating influence instead of an irritating aberration,[1] not just in the U.S. but in most industrialized economies. Thus past price projections, which are significant for most commodities, including energy, are of dubious accuracy.

Serious supply shortages have recently developed, especially in basic materials. The actions of the oil-producing nations with respect to the supply and price of petroleum, and of Canada with respect to the supply and price of natural gas, create considerable uncertainty about the outlook for two of our major sources of energy. Macroeconomics since Keynes has concerned itself with aggregate demand; the supply side of the picture is now catching up, not only contributing to rapid price increases but also limiting the ability of the economy to grow, as evidenced by the economic downturn following the 1973 oil embargo.

Economic forecasts made in November and December of 1973, are far off;[2] forecasters now cannot even decide on the trend of the economy for the coming year, let alone five or ten years from now. Thus, making projections about something as closely tied to economic conditions as energy consumption is risky business.

Finally, we are probably just beginning the debate over our national and regional goals, whether "more is better" should be displaced by "enough is best", (The Ford Foundation's phrases), whether the tradeoff between consumption and conservation will tilt more toward conservation, whether the full social costs of producing goods will be incorporated into prices for those goods, what the nature and extent of environmental protection activity should be, and what the implications of each of these questions are for energy and the economy.

The purpose of the foregoing discussion is not to suggest that we give up in despair over all the uncertainties involved in attempting to project our future energy consumption, but to emphasize that no one really knows for sure what will happen in the next decade, and that predictions advanced by either side - industry or conservationists - should be viewed accordingly. On the other hand, both industry and conservationists have valid and reasonable points to make, and an effort will be made to present both sides without becoming advocate for one or the other.

II. Just as Montana's economy has to be viewed within the framework of the U.S. economy, so must Montana's energy consumption be viewed within the framework of national energy consumption.

The growth rate in the United States' energy consumption peaked in 1973 at 4.8% per year,[3] a rate at which the volume of energy consumption would double in 15 years. A number of factors have led to this high rate of growth in consumption:

Until quite recently, energy was cheap compared to most other commodities. The real price (in constant dollars, adjusted for inflation) of energy actually declined in the period 1950-1970 (table 1). For example, the price of oil, which accounts for one half of the energy consumed in the U.S., rose by only 30% from

1948 to 1972 while the general price level rose 74%,[4] amounting to a substantial drop in the real price of oil. Similar declines in the real prices of natural gas and electricity occurred. During this period of declining real costs for energy, wages and incomes were rising,[5] leading to increased energy-intensiveness in production and increased use of energy-consuming products like larger, less efficient autos, air conditioning, color televisions, frost-free refrigerators, self-cleaning ovens, etc. In short, the past 20 years have been marked by greatly increased energy use, increased quantities and varieties of energy-consuming products and a supply of cheap and wastable energy. Estimates of the current energy waste in the U.S. range as high as 25% to 40%,[6] which seems rather high, but reflects the magnitude of the problem.

Other factors contributing to heavy use of energy included:

-Promotional advertising which directly encouraged the use of energy and indirectly added to consumption by promoting energy-consuming goods,

-Development of the interstate highway system which brought a rapid increase in long distance, high-speed auto travel,

-Subsidies to truck and air transportation which produced a shift away from the more energy-efficient railroads,

-Passenger air fares which increased only 8% from 1950-1970 while bus and rail fares increased 90% and 47% respectively,[7]

-Rate structures for natural gas and electricity which promoted consumption by offering large-volume users significantly lower prices,

-The growth of suburbia, encouraged by federal income tax breaks and federal loans, which produced a soaring consumption of gasoline for commuting and higher consumption of energy for individual homes.

With the exception of outright waste, no value judgements are intended here about the factors which have encouraged energy consumption; what may seem inappropriate in the light of our present energy situation was not necessarily inappropriate five, ten, or twenty years ago.

However, it is clear that times have changed, and while the U.S. energy consumption could continue to increase at a rapid rate, say 4.5% per year,[8] an easing in the rate of growth seems more probable for several reasons:

The consenses among economists seems to be that the recent increases are just the beginning of a period of energy prices catching up to a more realistic share of consumer expenditures. From April 1973 to April 1974, the price of natural gas rose over 12%; the price of gasoline over 66%; #1 Fuel Oil, 100%; Diesel fuel, over 60%.[9]

Large increases in price will provide incentive for voluntary conservation of energy. They will also make economical the replacement of inefficient machines and methods,[10] whereas in the past it was often cheaper to waste energy than to replace inefficient machinery. Rising energy prices may also encourage substitution of labor and materials for energy,[11] since these factors continuously compete as inputs in the productive process.

The magnitude of the price increases to come is, of course, impossible to predict with certainty, but average increases of about 50% in the next decade are not unreasonable. The Stanford Research Institute estimates prices in residential market should increase 4% to 6% per year, Prices to commercial users should rise as a rate somewhere between the two.[12]

Persistent increases of this magnitude have not been experienced before, thus there is little empirical evidence for predicting the effect on consumption. And because of the lag in response, the price increases of the last few years are too recent to fully know their effect.

The concept of price elasticity is used to measure the responsiveness of consumption to a change in price; it is defined as the % change in consumption divided by the % change in price. Thus, a price elasticity of -1.5 would indicate that consumption of a commodity would decrease 15% in response to a 10% increase in price. In general, elasticity does not have a time component; the response is considered to be immediate. But with respect to energy consumption, there is a long time interval required for changes in utilization patterns to take effect. We are stuck for the time being with our underinsulated homes, over weight cars, and inefficient machinery, but as these items are gradually replaced, the effect on consumption becomes apparent. Thus any response is considered to be long-run: 10 years or so.

Factors which affect the elasticity of a commodity include the availability of substitutes, the desirability or essentiality of the commodity, and the portion of the consumer's income represented by purchases of the commodity.[13] Each of these factors suggests that the non-waste consumption of energy will not be very responsive to price increases: There is no substitute for energy. (Although the different energy forms are sometimes substitutable). It is clearly essential in almost every aspect of our lives. And its relative cost has been quite low — 3.6% is the national average of the cost of energy used in the home as a percentage of disposable income, although a few states in the colder climates are over 5%.[14] Montana is in this latter range.

However, the wasteful energy consumption previously alluded to should be much more price-elastic.

Significant savings in private consumption of energy were observed during the "energy crisis" period of 1973, and conservation of specific fuels in a survey of business and industry ranged from 5-20%,[15] without disruption of production, revenue, or employment.

Areas where major savings are considered possible include: increased adoption of small cars with less power equipment, improvements in the efficiency of industrial products and processes (the more the price rises, the more means become economical for improving efficiency), better insulation and more efficient heating and cooling systems, and efforts at individual conservation. The combined effect of these conservation efforts might reduce energy consumption in the U.S. 20-30% by 1985 by one estimate (David Freeman, director of the Energy Policy Project, Ford Foundation) but a more realistic figure probably is 10-15% below what projections of current growth would indicate. (Table 2)

It should be noted that there will be an increased demand for energy for environmental protection. Fuel efficiency in cars is expected to drop 10-20%[16] and the share of energy for the environment will rise from 2% to 4%[17] by 1985.

In summary, domestic energy demands, despite conservation incentives, higher energy prices, technological changes, and more efficient industrial production will probably continue to grow steadily through the next decade, though at a reduced rate, perhaps 3-3½% per year, about 1% per year less than the average for the previous decade. (Table 3)

With regard to price elasticity, it is important to realize that there is a supply effect as well as a demand (consumption) effect. Supply of a commodity is generally elastic (responsive to price changes) if it can be produced in many different ways, if technology is on the brink of introducing new means of production, and if the system of distribution can be improved.[18] Energy meets all of these criteria, and has been highly price-elastic for the last 200 years.[19] The implications of this are obvious: rapid increases in price may cause a substantial increase in the supply of energy available in the next decade, and some economists believe this effect may be even more pronounced than the effect on consumption.[20] If the supply of energy does increase substantially, voluntary conservation will probably be forgotten, just as many people thought the energy problem was over when the oil embargo ended. This parenthetical note is not intended to negate the previous projection of a decreased growth rate, but rather to reinforce the original point that no one really knows what will happen in the next ten years.

III. With that in mind, we can move to the energy consumption picture for Montana. Unfortunately, the only firm forecasts available at this time are from the Northern Great Plains Region Energy Forecast through the year 2000, which projects extensive development of coal gasification in Montana by 1985, with a consequent 1985 energy consumption of more than 2½ times the 1971 consumption (Table 6), a rate of increase far higher than even the highest historical rates for the state or the nation.

Since there is considerable doubt about the likelihood of gasification on this scale in Montana, it would seem more useful to examine the average annual growth rate of energy consumption in Montana for the past decade (which was 3.2%) (Table 7) and try to identify those factors which would tend to speed up the consumption growth rate, and those which would tend to slow it down.

To emphasize an earlier point, projections of energy consumption in the state must be made within the framework of economic projections for Montana, which, of course, are ultimately dependent on the national outlook. Viewed in the light of our current national economic situation, the GNP for the next decade seems likely to grow more slowly than it did in the past decade; and this slowdown could be expected to affect Montana's rate of economic growth. Likewise, the probable decline in the growth rate of national energy consumption suggests that Montana's annual growth of energy consumption may fall below the previous decade's rate of 3.2% per year, since many of the factors which influence the national outlook are operative here, plus some additional factors:

-Utility rate structures may be redesigned to encourage conservation rather than consumption,

-We are nearing the end of new hydroelectric power sources, thus the end of plentiful and inexpensive electricity,

-Prices of all energy products will probably be rising faster than incomes, exerting downward pressure on consumption,

-Attitudes of the public seem less supportive of unquestioned economic and population growth,

-High rates of growth of energy consumption by energy-intensive industries may slow down in response to higher energy costs and introduction of new technologies such as ALCOA's new aluminum process (which is expected to increase efficiency by 30%)[21] plus the fact that the period of these industries moving into cheap power areas may end with the end of cheap power.

-The marked increase in energy use by agriculture will probably slow, since most mechanization has already been adopted, and further increases per unit of output are not expected.[22]

Individual conservation efforts may or may not have a significant impact in Montana, depending largely on individual attitudes. For example, if the State Legislature's proposed $1.00 fine for exceeding the 55 mph speed limit (later changed to $5.00) reflects most individual attitudes toward energy conservation, then conservation efforts may have little effect. One person is not likely to drive 55 to save gasoline so that another can drive 75.

In a larger sense, there is nothing inevitable about the growth of individual consumption; it is partly a matter of individual choice, based on decisions about the desired quality of the environment and the desired standard of living. It is unlikely that Montana residents will voluntarily alter their modes and standards of living in any radical way, but collectively they have the potential to achieve large savings in energy if they choose to do so. It remains to be seen whether they will.

Not all factors in the state point to decreased growth in energy consumption. As previously mentioned, environmental protection measures will tend to increase consumption. The stringency of requirements, the degree of enforcement, and the level of voluntary compliance to the regulations will determine the additional energy consumed.

The Montana Power Company anticipates the possible addition of such loads as 20-25 MW at Hoerner-Waldrof in 1977, 18 MW at U.S. Plywood in 1975, 25 MW at Ferrio-Chrome, 20 MW at Anaconda's Arbiter Copper Reduction plant, and perhaps 15 MW for metal recycling at Conrad. They also expect the requirement for power for agricultural irrigation to increase.[23]

Large increases in energy consumption by the electric utilities will occur if the planned growth of thermal generation facilities proceeds, since the BTU content of fuels consumed by these plants is considerably greater than the BTU content of the electricity generated.

The proposed construction of the generation plants at Colstrip is, of course, one of the hottest controversies in Montana. The utilities claim that Montana will experience power shortages in this decade without the Colstrip facilities, based on extrapolations of historical growth in Montana which indicate power consumption will grow at about 5-6% per year. Of course, they would justifiably rather be too high with their estimates than too low, since it would be preferable to cut back on generation if consumption lagged below predictions than to be caught without adequate capacity if consumption outran predictions.

However, electricity consumption is subject to the same constraints that have been mentioned before: higher prices, uncertain economic growth, conservation efforts, possible rate restructure, and changing public attitudes about growth. Thus it is quite possible that extrapolations of historical growth rates may prove too high. For example, the nation's use of electricity during this previous November, December and January ran 10% below expectations.[25] Bonneville Power Administration announced that since the regionwide energy conservation program began in August 1973, actual loads underran estimates by an average of 6.75% from September thru December of 1973. And the Montana Power Company's figures for the past 12-month period show a growth rate of 3.2%,[26] well under the 5-6% predictions.

These figures should be viewed with some caution, however. They represent much too short a time period to represent a significant trend for the future; a 12-month growth rate of 3.2% does not mean that the next decade will necessarily show that rate of growth. The eventual figure is more likely to be somewhere between that low figure and the previous expectation of 5-6%. Moreover, there are several factors which favor the long-term outlook for electricity consumption:

The uncertain supply status of natural gas and petroleum, and the likelihood that their prices will increase more rapidly than the price of electricity,[27] will tend to increase the consumption of electricity relative to the other two. Electrical efficiency has substantial potential for improvement, both in conversion and utilization.[28] Electricity is the best form of energy in terms of versatility and convenience at the point of use, and it can be made from many primary fuels, minimizing the problem of depleting resources. It is also favored for the long-term because the future basic sources of energy - fission reactors, fusion, solar - will produce electricity. Increased penetration (share of the market) by electricity seems likely; by 1985 it is expected that 15% more energy consumption will be electrical[29] close to one-half the total energy consumption. Thus to say that the utility company forecasts may be too high is not to say that additional generating facilities will not be needed, but that they may not be needed as soon as the utilities have estimated. There is little doubt, however, that electricity consumption will continue to grow substantially in the state and the region through the next decade.

With regard to Colstrip, and the export of Colstrip's electricity to other states, arguments have been made that Montana should look out for its own interests, and let other states take care of themselves. This ignores the interconnected network of electricity generation and transmission facilities which already comprise the western region's electric system, permitting greater efficiency and conservation by allowing the sharing of power during peak load periods. These arguments also ignore the fact that the states can no more be independent with respect to electricity than they can be in any other phase of commerce. It seems somewhat myopic to arbitrarily claim independence of other states on this one issue when in fact the economies of the state, region and nation are based on the continuous exchange of goods and services. At a time when both the energy and the economic situation are somewhat precarious in this nation, we need <u>more</u> interstate cooperation, not less.

TABLE 1

VALUE-WEIGHTED INDEX OF ENERGY PRICES, 1950-JUNE 1970 (1960=100)

Year	Index
1950	107.2
1955	103.9
1960	100.0
1965	93.5
1970	85.4

AVERAGE ANNUAL RATE OF CHANGE OF ENERGY PRICES, 1950-JUNE 1970

Period	Rate of Change
1950-55	-.62
1955-60	-.75
1960-65	-1.31
1965-70	-1.73

Source: An Energy Policy Primer

TABLE 2

ESTIMATED 1985 U.S. ENERGY DEMAND REDUCTION
(See Table 3 for comparison with total consumption)

Category	MBPD
By Conservation	
Industrial conservation measures	1.5
Transportation	
Lower speeds, car pooling	1.0
Airpland load factors	0.3
Space heating efficiency	1.0
By Use of Energy-Saving Equipment	
Smaller, more efficient cars	2.0
Other transportation savings	1.1
Better building insulation standards	1.1
Residential and commercial equipment	0.4
Industrial process efficiency	1.0
Total conservation potentials	9.4
Less 15 percent for partial overlap	8.0

To achieve the above, the physical requirements would be the following:

-Convert the automobile population from its present 30:70 ratio of small to large cars to at least an average of 50:50 by 1985. This will require the production of 75 million lightweight automobiles in the next 10 years.

-Expand mass transportation facilities in large cities.

-Ensure that construction of 20 million required housing units have substantially improved insulation.

-Make industrial processes 10 percent less energy-intensive, on the average.

-Do without energy through economy measures and more efficient energy space heating like heat pumps.

Beyond this is the reduced dependence on oil through greater use of coal and nuclear fuel sources. In 10 years the pressure on petroleum fuel can be reduced substantially, provided barriers to direct use of coal and nuclear fuel for electricity are removed.

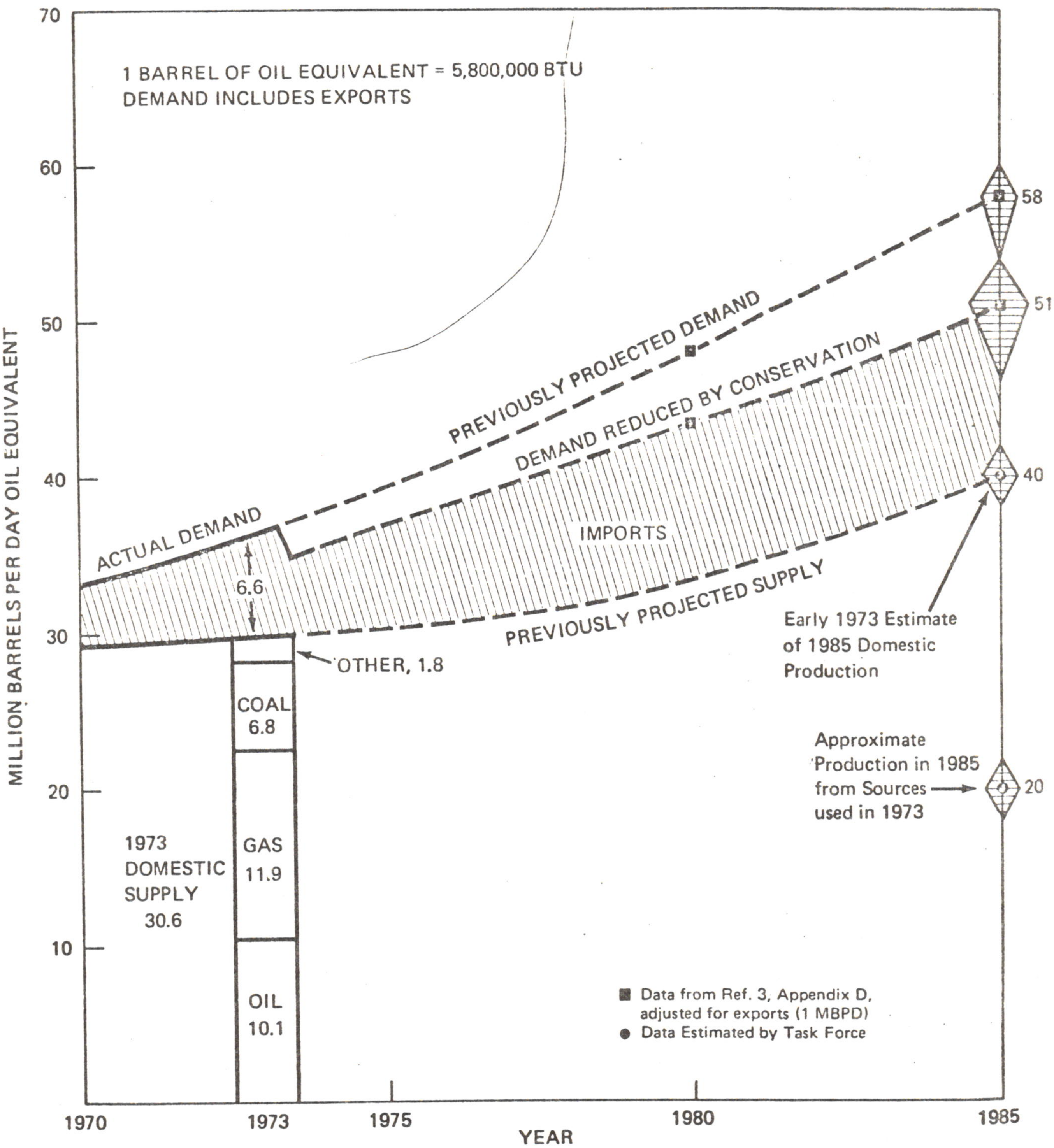
POSSIBLE GOVERNMENT ACTIONS

Many of the results above can be achieved through the normal working of the Nation's economic system. However, government can play an important contributing rôle through the following actions; indeed, government leadership may be the key to effective conservation achievements.

Source: U.S. Energy Prospects

TABLE 3

U.S. ENERGY SUPPLY AND DEMAND



Source: US Energy Prospects

TABLE 4

Appendix C 1985 Demand or Consumption - MBPD[a] (Million Barrels of Oil per Day)

Energy Source	1972, NPC-Low Level[10]	1972, NPC-Intermediate Level[10]	1972, NPC High Level	1972, Associated Universities, Inc.[39]	1972, Department of the Interior[1]	1972, Stanford Research Institute[36]	1973, Council on Environmental Quality[37]	1972, Shell Oil[38]	1973, Energy Policy Office[3]
FOSSIL FUELS									
Petroleum				24.19	25.0	32.0	25.49		
Coal				10.20	10.63	7.2	10.15		
Gas				12.55	14.05	14.0	13.61		
Total fossil fuels				46.94	49.68	53.2	49.25		
OTHER									
Nuclear, Hydro, Geothermal				8.18	7.96	14.3	9.16		
GRAND TOTAL	53.2	59.0	61.3	55.12	57.73	67.5	58.41	62.0	57.0
Demand (D) or Consumption (C) Type Projection	D	D	D	?	C	D?	C?	C	C

	Range - MBPD High	Low
Petroleum	32.0	24.2
Coal	10.6	7.2
Gas	14.1	12.6
Total Fossil Fuels	53.2	46.9
Geothermal, Nuclear, Hydro	14.3	8.0
GRAND TOTAL	67.5	53.2

Source: U.S. Energy Prospects

TABLE 5

The approximate 1973 consumption of energy, according to the major areas of use, was:

ESTIMATED 1973 U.S. ENERGY-USE PATTERN[a]

Use Area	Percentage of National Use	Equivalent MBPD
Transportation	25	8.82
Space heating	18	6.39
Process steam	16	5.75
Direct heat	11	3.87
Electric drive	8	2.73
Lighting	5	1.97
Water heating	4	1.44
Feedstocks	4	1.29
Air conditioning	3	1.09
Refrigeration	2	0.69
Cooking	1	0.35
Electrolytic processes	1	0.45
Other	2	0.84
Total	100	35.68

[a]Developed by extrapolating 1960-1968 relative trend data by use area[4] and applying to total estimated energy consumption in 1973.[2] The difference between this energy consumption and the energy demand in Chapter 2 (37.2 MBPD) is accounted for by exports and changes in stocks.

Transportation uses more energy than any other single area. It is uniquely dependent on oil as the only fuel system presently suited to the mobility of the U.S. life style. It is the area for the greatest efficiency imporvement, as will be reviewed in the next section.

Other major opportunities for reducing waste and improving energy efficiency lie in energy supply for the following:

	1973 Estimated Percent of Total Energy Use
Space heating	18
Process steam	16
Direct heat	11
Water heating	4
Lighting	5
Total Opportunity	54

Source: U.S. Energy Prospects

TABLE 6

Montana Consumption of Energy Resources by Major Sources and Consuming Sectors, 1971 actual, and projected to the year 2000[1/]
(in trillion Btu's)

	Coal	Petroleum	Natural gas	Total fossil fuels	Hydro-power	Total Gross Inputs	Utility Electricity Distributed	Net Inputs
1971								
Household & Commercial	3.7	22.4	42.3	68.4	---	68.4	11.2	79.6
Industrial	1.1	13.1	50.5	64.7	---	64.7	23.1	87.8
Transportation	---	76.4	1.0	77.4	---	77.4	0.3	77.7
Electrical Generation	17.4	---	1.1	18.5	98.3	116.8	(34.6)	---
Miscellaneous	---	25.6	---	25.6	---	25.6	---	25.6
Synthetic Gas	---	---	---	---	---	---	---	---
Total	22.2	137.5	94.9	254.9	98.3	352.9		270.7
1975								
Household & Commercial	3	24	47	74	---	74	13	87
Industrial	1	18	58	77	---	77	29	106
Transportation	---	83	1	84	---	84	insig.	84
Electrical Generation	19	---	1	20	99	119	(42)	---
Miscellaneous	---	22	---	22	---	22	---	22
Synthetic Gas	---	---	---	---	---	---	---	---
Total	23	147	107	277	99	376		299
1980								
Household & Commercial	2	28	53	83	---	83	16	99
Industrial	1	25	69	95	---	95	35	130
Transportation	---	90	1	91	---	91	insig.	91
Electrical Generation	139	---	1	140	110	250	(51)	---
Miscellaneous	---	18	---	18	---	18	---	18
Synthetic Gas	---	---	---	---	---	--	---	---
Total	142	161	124	427	110	537		338
1985								
Household & Commercial	1	32	58	91	---	91	18	109
Industrial	1	33	80	114	---	114	42	156
Transportation	---	96	2	98	---	98	insig.	98
Electrical Generation	171	---	1	172	119	291	(60)	---
Miscellaneous	---	13	---	13	---	13	---	13
Synthetic Gas	340	---	---	340	---	340	---	340
Total	513	174	141	828	119	947		376
2000								
Household & Commercial	---	44	75	119	---	119	26	145
Industrial	2	55	116	173	---	173	61	234
Transportation	---	116	2	118	---	118	insig.	118
Electric Generation	222	---	2	224	140	364	(87)	---
Miscellaneous	---	---	---	---	---	---	---	---
Synthetic Gas	681	---	---	681	---	681	---	---
Total	905	215	195	1,315	140	1,455		497

1/ Based on Scenario II of the Coal Supply Forecast
Source: Northern Great Plains Resource Counc

Table 7. Total Consumption of Energy Inputs, Montana, 1960-1971 (Trillion Btu)

Year		Bituminous coal & lignite	Petroleum products	Natural gas	Total fossil fuels	Hydropower & nuclear power	Total gross energy	Utility electricity distributed	Total Net energy inputs
1960		10.7	120.9	55.7	187.3	62.4	249.7	17.4	199.8
1961		10.9	120.7	58.5	190.1	69.2	259.3	17.9	202.7
1962	2.5%	11.3	120.8	64.9	197.0	67.7	264.7	18.9	206.7
1963	per	11.8	121.2	67.5	200.5	63.0	263.5	19.5	210.7
1964	year	12.6	121.9	69.9	204.4	71.4	275.8	21.3	216.7
1965		13.9	123.0	72.0	208.9	87.7	296.6	23.5	223.5
1966	3.8%	14.6	124.4	77.1	216.1	82.7	298.8	26.6	231.4
1967		15.6	126.2	78.0	219.8	90.8	310.8	25.7	235.7
1968		16.8	128.3	82.0	227.1	92.8	319.9	29.2	244.6
1969		18.3	130.8	86.9	236.0	98.7	334.7	34.5	256.1
1970	3.3%	20.0	133.8	92.0	245.8	91.8	337.6	34.1	262.4
1971		22.2	137.5	94.9	254.6	98.3	352.9	34.6	270.7

3.2% average overall, a 40% increase in 11 years

Source: Northern Great Plains Resource Council

IX. MAJOR STATE AND NATIONAL ENERGY REGULATION

Outline and Functional Key

(Read across the energy flow process and down to the source of energy to discover to governmental units (state and federal) charged with regulating the situation. The Roman numerals, letters and Arabic figures refer to the descriptive outline of regulatory policies that follows this key. Thus: Coal extraction is supervised by the state Lands Department under procedures described in Parts A1 and B1-3 of the state outline, which happens to begin on the next page.)

	Exploration and Extraction	Transportation	Processing or Conversion	Consumption
Coal	State: Surface Mining, DSL: A1, B1-3 Federal: I, A,B	State: Unit Trains, PSC:2; Slurry Pipe, DNR: B2; Transportation of secondary coal products, B1 Federal: I, C	State: Electrical generating plants, gasification, liquidfaction, DNR: A,1 Federal: I, D	
Electricity	State: Hydropower leasing sites DSL: A5 Federal: VI	State: Transmission lines, DNR: A1 Federal: II, A	State: Electrical generating plants, DNR: A1	State: Electrical rate, PSC:B Federal: II, B
Petroleum and Natural Gas	State: DNR: C1 Federal: III, A,B	State: PSC: A1 Federal: III, C	State: Air and water pollution from refinery, DHES: B1-2 Federal: III, D	State: Petroleum Transportation rates, PSC: B1
Uranium and Nuclear	State: Surface mining, DSL: A1, B1-2; All types, DHES: A1; Solution mining, DHES: A2 Federal: IV, A,B	State: DHES: A1 Federal: IV, C	State: Enrichment plant, DNR: A1; Milling control of tailings, DHES: A1 Federal: IV, C	
Geothermal	State: DNR: A1	State: Power lines, DNR: B2	State: DNR: A1 Federal: V, A	State: Electrical energy rates, PSC: B1

DSL: Department of State Lands
DNR: Department of Natural Resources
DHES: Department of Health and Environmental Sciences
PSC: Public Service Commission

State and Federal Energy Regulation

State (by agency)

Department of State Lands (DSL)

A. leasing: The Board of Land Commissioners may lease state lands which includes land under navigable lakes and streams and lands which have been sold but the state reserved mineral rights for (except where the U.S. has reserved mineral rights).

1. coal: (81-501-510); may lease state lands for mining and selling of coal. It may lease lands for coal which have been sold but where the state reserved mineral rights. The statute contains a provision which requires that coal be developed to prevent waste and to prevent future mining operations from being "more difficult or expensive." There is not specific reference in the statutes to minimization of damage to environment.

2. uranium: (81-601-620); uranium is included in the leasing provisions for metaliferrous minerals. The state may lease land for this purpose or it may grant prospecting permits without a lease. Royalties received from these mining leases are not less than 55% of the full market value or of the returns from the metals removed or reserved mineral rights covered by lease. State land can

State (cont.)

Department of State Lands (cont.)

be leased for multiple uses, ie., uranium and coal.

3. oil and gas: (81-1701-1731): oil and gas may be leased on such lands where agriculture and grazing leases also exist, but must be protected from destruction or harm by the oil and gas lessee. In every oil and gas lease, the state reserves the right to sell, lease or otherwise dispose of the surface of the lands, subject to the rights of the oil and gas lessee. All oil and gas leases are subject to certain conditions of proper management of the resource.

4. geothermal: (31-2601); The 1974 legislature empowered the Board of Land Commissioners to lease state lands for the prospecting, exploration, well construction, and the production of geothermal resources. All leases are for a primary term of ten years and for so long thereafter as geothermal resources in paying quantities are produced as long as the terms of the lease are met.

5. hydropower sites: (81-1801); Leases and licenses of fifty-year terms for the development of hydropower may be issued by the Board. It is not permissable for the Board to advertise for sale or sell state lands constituting power sites or parts of power sites. The Board may also cooper-

State (cont.)

Department of State Lands (cont.)

ate with the Federal government in joint development of a site.

B. exploration and extraction: coal and uranium, surface mining.

1. Strip Mine Siting Act: (50-1601); regulates coal and uranium surface mining, requires an application for a mine site before any preparatory work is done. Application may be refused on the grounds that the mine site is not consistent with the Reclamation Act.

2. Strip Mine Reclamation Act: (50-1036); regulates coal and uranium surface mining, and prospecting. An application and bond is required for both strip mine and prospecting permits. The application must contain a detailed reclamation, revegetation and rehabilitation plan for the land and water to be affected. The application must be accompanied by a $50 fee and a bond of not less than $200 an acre or more than $2,500 an acre as determined by the board. The bond cannot be replaced sooner than five years after mining has stopped. In applying for a prospecting permit, the applicant must submit a prospecting map and reclamation plan primarily the same as those for strip mining. Both permits are good

Department of State Lands (cont.)

for one year and may be renewed, suspended, or revoked by the board for noncompliance.

The department cannot approve an application if the information and inspections indicate the act's purposes will not be fulfilled. Also, the application can be denied if the affected area has special, critical, or unique characteristics. These include areas of biological productivity, the loss of which jeapordizes certain species of wildlife or domestic stock; or ecological fragility, to the sense that the land, once adversely affected, could not return to its former ecological role in the reasonable foreseeable future; or ecological importance, in the sense that the particular land has such a strong influence on the total ecosystem of which it is a part that even temporary effects felt by it could precipitate a system-wide reaction of unpredictable scope or dimensions; or scenic, historic, archeologic, topographic, geologic, ethnologic, scientific, cultural or recreational significance.

3. Coal Conservation Act: (50-1403); regulates the extraction of coal in that marketable coal cannot be wasted nor mined in a surface mine. It requires a two-year permit and there are civil penalties for non-compliance.

Department of Natural Resources (DNR)

A. processing and conversion of coal

1. Utility Siting Act: (70-801); requires that plants to convert coal, in electric steam generation plants, gasification plants and liquidfaction; as well as uranium enrichment and geothermal facilities and facilities associated to these types of plants must receive a certificate of public need (for facility) and environmental compatability.

B. transportation (of coal in processed forms)

1. Utility Siting Act: (70-801); requires that all

a. electric transmission lines carrying 34.5 kilovolts (kv) or more (except 69 kv lines or less above ground less than 10 miles, or 161 kv lines or less underground less than 5 miles in length or 161 kv lines or less, 30 miles in length or less) shall be covered by the act and will require a permit. Lines which carry gas or liquid hydrocarbons from the gasification or liquidfaction plants are also covered under the act. All require a certificate of public need and environmental compatability.

2. Water Use Act: (89-867); declares that water for slurry pipe transportation of coal is not a beneficial use; therefore, water cannot be used for that purpose.

State (cont.)

Department of Natural Resources (cont.)

C. extraction and exploration of oil and gas

1. Oil and Gas Conservation Division: (36-18020); covers oil and gas extraction, grants permits for oil and gas drilling; it contains prodivisions which prohibits waste of gas and oil in the extraction process. Steps have been taken to maximize utilitization of both oil and gas from a well with high oil/gas ratio where before natural gas was wasted. Also, there are programs to help secondary recovery of oil.

Public Service Commission (PSC)

A. transportation of oil and gas, coal

1. The public service commission has the authority to supervise, regulate and control all public utilities. This would include railways, gas and electric utilities, commercial trucking and intra-state pipelines for oil and gas. It grants permits on public convenience and necessity. It also regulates rates for these services.

B. consumption: electricity

1. The Public Service Commission has the authority to grant or deny rate increases for electricity, natural gas and fuel oils. Their raising the price of energy would have an effect upon the consumption of energy in that people generally use less when the cost is significantly more.

State (cont.)

Department of Health and Environmental Sciences (DHES)

A. extraction of uranium

1. Radiation Control Act: (69-5801); regulates all aspects of pollution from radioactive sources. It also regulates health and safety of workers of radioactive sources. Some functions of this act are administered by AEC (primarily those beyond mining activities) however, the state could assume this function by gaining agreement status. (This is being considered.)

2. Water Quality Act: (69-4807); would regulate pollution from solution mining from other than radioactive sources, ie., acidic leaching substances contaminating groundwater.

B. regulation of processing or conversion; petroleum

1. Water Quality Act: (69-4507); regulates effluents from refineries according to standards.

2. Air Quality Act: (69-3904); regulates effluents from refineries into air according to standards.

Energy Regulation

Federal (by activity)

I. Coal Extraction and Exploration

A. Exploration

1. Bureau of Land Management. Grants permits for prospecting (survey and exploration) on public domain and acquired lands which, at the time of issuance, are not known to contain workable coal deposits. Coal prospecting permits contain provisions which give permittees preference rights to coal leases should commercial quantities of coal be discovered. Lands known to contain workable coal deposits are leased through competitive bids.

2. Forest Service. Grants special land use permits for geological and geophysical prospecting) on Forest Service administered lands which have not yet been leased. Receives lease applications and makes recommendations and provides stipulations to BLM prior to issuance of lease.

3. U.S. Geological Survey. Reviews survey and exploration permit applications submitted to BLM prior to leasing.

B. Extraction

1. Bureau of Land Management. Conducts competitive coal lease sales on the public domain and acquired

Coal Extraction and Exploration (cont.)

lands, including lands administered by the Forest Service and lands that comprise the Wildlife Refuge System. Issues preference right leases when permittee qualifies.

2. U.S. Geological Survey. Evaluates data and provides advice to BLM regarding areas proposed for leasing; approves mining plans, and supervises operations conducted under BLM coal leases.

3. Forest Service. Regulates access roads that lead across Forest Service lands to areas leased for coal production; Forest Service reviews leasing actions proposed by the BLM and recommends stipulations to be included in such leases. Coal mining operations on leased Forest Service lands are regulated by the USGS. Forest Service public domain lands can be leased without Forest Service concurrence; Forest Service acquired lands can be leased only with Forest Service concurrence.

4. Bureau of Sport Fisheries and Wildlife. Provides advice and assistance regarding actions proposed by BLM to lease coal and recommends stipulations to be included in such leases.

C. Transportation

1. Railways to new mines

Forest Service. Grants rights-of-way across lands it administers.

Federal (cont.)

Coal Extraction and Exploration (cont.)

Corps of Engineers. Issues permits for activities in or affecting navigable waters.

Bureau of Sport Fisheries and Wildlife. Provides advice and assistance with regard to right-of-way granting action by BLM or Forest Service and recommends stipulations to be included in such permits.

States. Issue land use permits in accoradnce with applicable laws.

D. Processing and conversion (water)

1. Bureau of Reclamation may sell federal water to industrial users for conversion facilities.*

2. Corps of Engineers. Issues permits for activities in or affecting navigable water.

3. Bureau of Sport Fisheries and Wildlife. Reviews Corps of Engineers permit granting action and recommends stipulations to be included in such permits. There is no federal siting law at this time, one has been proposed in congress.

II. Electricity

A. Transportation

1. Forest Service. Grants rights-of-way across lands it administers.

*It is unclear whether Bureau of Reclamation can sell water for industrial purpose and what would constitute federal water under Bureau of Reclamation jurisdiction rather than a state agency.

Federal (cont.)

Electricity (cont.)

2. Bureau of Land Management. Grants rights-of-way across lands it administers.
3. Corps of Engineers. Grants permits for stringing of lines navigable waters.
4. Bureau of Sport Fisheries and Wildlife. Provides advice and assistance regarding proposed right-of-way granting actions by BLM or Forest Service and recommends stipulations to be included in such right-of-way permits. Provides advice and assistance to Corps of Engineers with regard to permit granting action and recommends stipulations to be included in such permits.
5. Atomic Energy Commission. Considers power line routes in granting construction license for nuclear power plants.
6. Federal Power Commission. Considers power line routes in authorizing construction of primary lines from licensed non-Federal projects on lands subject to Federal jurisdiction.

B. Consumption: F.P.C. regulates interstate wholesale power rates.

III. Petroleum and Natural Gas

A. Exploration

1. Bureau of Land Management. Receives notification of survey and exploration prior to leasing on public domain and acquired lands.

Federal (cont.)

Petroleum and Natural Gas (cont.)

8 2. Forest Service. Grants survey and exploration permits on Forest Service administered lands which have not yet been leased.

3. U.S. Geological Survey. Reviews survey and exploration permit applications submitted to the BLM prior to leasing.

B. Extraction

1. Bureau of Land Management. Conducts oil and gas lease sales on the public domain and acquired lands, including lands administered by the Forest Service and lands that comprise the Wildlife Refuge System.

2. U.S. Geological Survey. Evaluates data and provides advice to BLM regarding areas proposed for leasing, approves production plans and supervises operations conducted under BLM oil and gas leases.

C. Transportation

1. Federal Power Commission. Issues certificates for construction and operation of interstate gas (not oil) pipelines. In determining whether a pipeline should be granted,FPC takes siting and land use into account.

2. Bureau of Land Management. Grants pipeline rights-of-way across lands it administers which include, for purposes of transportation of oil and gas, National Forest lands reserved from the public domain.

Federal (cont.)

Petroleum and Natural Gas (cont.)

3. Bureau of Sport Fisheries and Wildlife. Provides advice and assistance regarding proposed rights-of-way granting actions by BLM or Forest Service and recommends stipulations to be included in such right-of-way permits. Reviews Corps of Engineers permit granting action and recommends stipulations to be included in such permits.
4. Forest Service. Grants pipeline rights-of-way across land it administers.
5. Corps of Engineers. Issues permits for activities in or affecting navigable waters.

D. Processing or conversions

1. States. Issue land use permits per applicable laws.
2. Corps of Engineers. Issues permits for activities in or affecting navigable waters.
3. Bureau of Sport Fisheries and Wildlife. Reviews proposed Corps of Engineers permit granting action and recommends stipulations to be included in scuh a permit.
4. National Oceanic and Atmospheric Administration. Reviews proposed actions by Federal agencies to grant permits which affect marine life and their habitat.

IV. Uranium

A. Exploration

1. Bureau of Land Management. Exploration for uranium

Federal (cont.)

Uranium (cont.)

and thorium on BLM administered public domain lands is in accordance with the Mining Law of 1872; no permits are required. On acquired lands, exploration for uranium and thorium requires a permit if lands are not known to contain workable uranium or thorium deposits. Such a permit contains provisions which give permittees preference rights to lease commercial deposits of uranium and thorium. Acquired lands known to contain workable uranium or thorium deposits are leased through competitive bids. On acquired lands, permits are required for any road building done in conjunction with survey and exploration even when such a survey and exploration does not require a permit.

2. Forest Service. Exploration for uranium and thorium on public domain lands administered by the Forest Service is done in accordance with the Mining Law of 1972; no permits are required for prospecting although permits are required for roads built in conjunction with such surveys. Prospecting for uranium and thorium in Wilderness and Primitive areas does require Forest Service permits. On acquired lands, Forest Service reviews applications. It provides BLM with recommendations and stipulations prior to issuance of leases

Federal (cont.)

Uranium (cont.)

which must have Forest Service consent.

3. U.S. Geological Survey. On acquired lands, reviews survey and exploration permit applications submitted to the BLM. Approves exploration plans and monitors activities conducted under BLM permits.

B. Mining and milling

1. Bureau of Land Management. Production of uranium and thorium on public domain lands is done under the Mining Law of 1872 and does not require a permit. A BLM permit may be required to construct access roads to uranium and thorium mining areas. Uranium and thorium located on acquired lands administered by the BLM are leased in the same fashion as coal, oil and gas.

2. Forest Service. Production of uranium and thorium on public domain lands administered by the Forest Service is done under the Mining Law of 1872 and does not require a permit. However, such production operations on Forest Service administered public domain lands must be in accordance with Forest Service lands to uranium and thorium mining areas. Uranium and thorium located on Forest Service acquired lands is leased by the BLM subject to stipulations required by the Forest Service.

3. U.S. Geological Survey. On acquired lands, USGS evaluates data and provides advice to BLM regarding areas proposed for leasing. Approves mining plans,

Federal (cont.)

Uranium (cont.)

and supervises operations conducted under BLM uranium and thorium leases.

4. Atomic Energy Commission. Promulgates and enforces regulations, and licenses uranium and thorium milling facilities at particular sites. (limited acreages suspected to contain minerals from which nuclear fuels might be produced have been withdrawn from the public domain and placed under the jurisdiction of the AEC for purposes of leasing uranium and thorium).

5. Bureau of Sport Fisheries and Wildlife. Provides advice and assistance with regard to action proposed by the BLM to lease uranium/thorium; recommends stipulations to be included in such leases.

C. Transportation and conversion

1. Atomic Energy Commission regulates the transportation and conversion of radioactive materials unless a state has achieved "agreement status." Montana has not.

V. Geothermal Generation

A. Generation

1. Bureau of Land Management. Conducts geothermal steam lease sales and issues on the public domain and acquired lands, including lands administered by the Forest Service and lands administered

Federal (cont.)

Geothermal Generation (cont.)

by the Forest Service and lands that comprise the Wildlife Refuge System.

2. U.S. Geological Survey. Evaluates data and provides advice to BLM regarding areas proposed for leasing; regulates operations conducted under BLM geothermal steam leases.

3. Forest Service. Regulates access roads that lead across Forest Service administered lands to areas leased for geothermal steam production. The Forest Service reviews leasing actions proposed by BLM and recommends stipulations to be included in such leases. Geothermal steam operations on leased Forest Service lands are regulated by the USGS.

4. Bureau of Sport Fisheries and Wildlife. Provides advice and assistance regarding actions proposed by BLM to lease geothermal steam; recommends stipulations to be included in such leases.

VI. Hydropower
(other than Federal projects)

1. Federal Power Commission. Issues preliminary certificates and licenses for construction and operation of non-Federal hydro projects on water or lands subject to Federal jurisdiction and in so doing, takes into account merits of site.

2. Forest Service. Issues permits for use of Forest

Federal (cont.)

Hydropower (cont.)

Service lands necessary for construction and operation of non-Federal hydro-projects.

3. Bureau of Sport Fisheries and Wildlife. Provides advise and assistance with regard to proposed action by the FPC to certificate non-Federal hydro projects; recommends stipulations to be included in such certificates.

X. CURRENT ENERGY TAXATION SYSTEM

Existing Fossil Fuel Taxes

There are currently a number of taxes levied upon the extraction, conversion, and distribution of oil, coal and natural gas in Montana:

1. Net Proceeds Tax (oil, coal, gas)
2. Resource Indemnity Trust Tax (oil, coal, gas)
3. Corporation License (Income) Tax (oil, coal, gas)
4. Oil Producers License Tax
5. Coal Mine License Tax
6. Natural Gas Distributors License Tax
7. Oil and Gas Conservation License Tax

Other resource extraction taxes: Personal Property Tax on equipment and real estate and "Right of Entry" property tax.

The following is an outline of these taxes:[1]

I. Net Proceeds Tax

A. Imposed on mining, oil and gas well operators, and owners of royalty interests.

B. Taxes on valuation of annual net proceeds and royalty interests of firm.

"The valuation of the net proceeds is basically determined in two steps: first, to determine net proceeds, then to determine the valuation of net proceeds. Net proceeds is the gross dollar value of product taken from a mine minus the cost of extracting and selling that product."[2] These costs include:

1. All royalties due to owners of royalty interests. In the case of oil

and gas the operators also pay the taxes due from the royalty owners and deduct these taxes from their gross royalty payments. Owners of coal royalties pay their royalty taxes directly.

2. All mining labor, machinery, and supplies.
3. The costs of improvements, repairs and betterment of the property (reclamation).

The valuation of the firm's net proceeds is whichever is the smaller of:

1. net proceeds averaged over five years or
2. net proceeds averaged for the number of preceeding years that the mine has been yielding, and in either case, years with zero yield may not be included.

C. Rate: subject to county-wide millage and state mill levy on property (100% of assessed value).

D. Distribution to state and county as all other tax revenue from property taxation (90 per cent county, 10 per cent state).

E. Reference: Title 84, Chap. 62 R.C.M., 1947.

F. Payment Schedule:

   1. Production statements due March 31 yearly.
   2. Net proceeds valuations computed and transmitted to assessors by July 1.
   3. Tax levies fixed by county commissioners on second Monday in August.
   4. Taxes computed by assessors by September 15.
   5. One-half taxes payable by November 30 and one-half payable May 31 following.

II. Resource Indemnity Trust Tax

A. Imposed on nonrenewable resource extracting industries.

B. Taxes gross (marked) value of annual product.

C. Rate: \$25 plus .5 per cent of gross value of annual product in excess of \$5,000.

D. Distributed to resource indemnity trust account for environmental improvement.

E. Reference: Title 84, Chap. 70 R.C.M., 1947.

F. First year taxable: 1973.

G. Payable by March 31 following calendar year production.

III. Corporation License Tax (Income Tax)

A. Applied to all corporations in Montana.

B. Taxes annual net income from business in the state.

C. Rate: 6.75 per cent of annual net income derived in Montana--minimum \$50.

D. Distribution:

1. General fund: 64 per cent.

2. Long-range building program: 11 per cent.

3. State school equalization fund: 25 per cent.

E. Net income is defined in section 84-1502 R.C.M., 1947 much as defined in internal revenue code.

F. Reference: Title 84, Chap. 15 R.C.M., 1947.

G. Changes:

1. Rate raised from 5.25 per cent to 5.50 per cent in 1967 session; to 6.25 per cent in 1969 session, and 6.75 per cent in 1971 session.

2. Allocation to long-range building program raised to 11 per cent from 5 per cent in 1967 session.

H. Payable on 15th day of 5th month following close of taxable year.

IV. <u>Oil Producer's License Tax</u>

A. Imposed on oil producers.

B. Taxes total gross (market) value of net output.

C. Rate: 2.1 per cent of total gross value of product up to 450 barrels per producing well in the calendar quarter. Rises to 2.65 per cent of total gross value of product in excess of 450 barrels per producing well in the calendar quarter. Output used in connection with production not taxed.

D. Distribution: General Fund.

E. Reference: Title 84, Chap. 22 R.C.M., 1947.

F. Rates changed from 2 per cent and 2.5 percent to 2.1 per cent in 1969 session. Quarterly filing date changed in 1973 session.

G. Payable quarterly within 60 days of end of calendar quarter.

V. <u>Strip Coal Mines License Tax</u>

A. Imposed on strip mine coal producers.

B. Taxes net physical production by ton.

C. Rates: (cents per ton of coal with the listed heating values per pound.)

1. 12 cents up to 7,000 BTU.
2. 22 cents over 7,000 up to 8,000 BTU.
3. 34 cents over 8,000 up to 9,000 BTU.
4. 40 cents over 9,000 BTU.

D. Distribution: three cents per ton to county General Fund, balance to state General Fund.

E. Reference: Title 84, Chap. 13 R.C.M., 1947.

F. Payable quarterly within 30 days of end of calendar quarter.

VI. Natural Gas Distributors License Tax

A. Imposed on distributors, not necessarily producers, of natural gas.

B. Taxes on the volume of natural gas produced, within or outside the state, and distributed to consumers in Montana for use within or outside the state.

C. Rate: .575 per cent per 1,000 cubic feet.

D. Distribution: General Fund.

E. Reference: Title 84, Chap. 21 R.C.M., 1947.

F. Rate changed from one-half cent to current rate in the 1969 session.

G. Payable quarterly within 30 days of end of calendar quarter.

VII. Oil and Gas Conservation License Tax

A. Imposed on operators and producers of oil and gas to defray the expenses of the oil and gas conservation commission.

B. Taxes the production of oil by barrels and gas by cubic foot.

C. Rates:

OIL

1. On leases with wells producing fewer than 25 barrels per day, up to three-eighths cents per barrel.

2. On leases with wells producing more than 25 barrels per day, not more than three-fourths cents per barrel.

NATURAL GAS

1. On gas marketed for less than 15 cents per 1000 cubic feet, not more than 2.5 mills per 10,000 cubic feet.

2. On gas marketed for 15 cents or more per 1000 cubic feet, up to 5 mills per 10,000 cubic feet.

(Assessments set by oil and gas commission in accordance with its own needs. In addition, a variable fee is charged for drilling permits depending on depth of test well or core hole.)

D. Distribution: Earmarked revenue fund for oil and gas conservation commission. If commission is dissolved, money remaining in this fund reverts to general fund.

E. Reference: Title 60, Chap. 1 R.C.M., 1947.

F. Tax payable quarterly within 30 days of end of calendar quarter.

VIII. Personal Property Tax on Equipment and Real Estate

A. Taxes owners of industrial equipment and real estate.

B. Machinery, equipment and real estate assessed at 40 per cent of market value. The taxable value is 30 per cent of assessed value.

C. Rate hinges on county and state mill levies.

D. Distribution: 90 per cent to the county and 10 per cent to the state.

(An important exemption is "new industrial property," which is taxable for the first three years of operation only at 7 per cent of its assessed value, not 30 per cent.)

IX. "Right of Entry" Property Tax

A. Taxes owners of mineral wealth for their "right to enter land for digging, prospecting, or exploration."

B. Mills are levied on taxable value, here set at 100 per cent of assessed value, which can be the price the owner paid for the land but historically has been 25 to 50 cents an acre.

C. Distribution: similar to other property taxes.

It is evident that the current tax system om Montana energy sources is neither simply designed nor consistent among the three fossil fuels. Peculiarly, the Natural Gas Distributor's License Tax applies only to natural gas which is sold and distributed to consumers within Montana. It does not apply to gas produced within the state and distributed directly to out-of-state customers.[4] Exported natural gas probably should be taxed like other exported fossil fuels.

Taxes on oil, coal and natural gas are paid at different times during the year. The Strip Coal Mines License Tax, Oil and Gas Conservation License Tax, Natural Gas Distributors License Tax and the Oil Producers License Tax all are paid quarterly. The Net Proceeds Tax is payable semi-annually and the Resource Indemnity Trust Tax is paid annually.

Coal taxes variously are based on gross value (resource indemnity), gross value minus deductibles (net proceeds), and physical production and BTU content (mines license tax).

Oil men pay net proceeds and resource indemnity taxes, a tax based on gross value of the oil but varying with quarterly production per well (Producers License Tax), and a tax based on production but varying according to daily production rate (Oil and Gas Conservation License Tax).

Natural gas producers pay the resource indemnity, net proceeds, and gas conservation taxes, and a tax based on the value of the gas they distribute (Distributor's License Tax).

Some Difficulties

The Net Proceeds Tax is particularly troublesome and unpredictable among the state's energy resource taxes. For this tax, allowable deductions include reclamation expenses (greatly divergent among strip mining companies), royalties, and in some cases, even profits. But for the local jurisdiction that levies assessments on the elusive "net proceeds," the nature of the tax is its worst failing: unpredictably hinging on the earnings, profits, and costs of what usually is the dominant corporate taxpayer in a jurisdiction, the proceeds tax cannot be depended on from year to year either by government or the more numerous citizen taxpayers, who must adjust their payments to compensate for the irregular successes of the Net Proceeds Tax.

The deduction of land reclamation costs, a variable item, can substantially reduce local tax receipts as Table I[5] shows:

Table I - Peabody Coal Company Taxes
in Rosebud County School District No. 19 (1973)

	Without Reclamation Deduction	With Reclamation Deduction
Taxable Net Proceeds	$640,655	$191,188
Taxes Owing	$86,258	$25,742

In estimating its reclamation costs at $449,467, Peabody Coal was saying that reclamation cost $12,500 an acre during the year. Burlington-Northern Railroad, which is trying to reclaim old spoils banks in the same county, and Western Energy, which is attempting concurrent reclamation and mining nearby, both indicate reclamation costs of about $700 an acre.[5]

Royalty payments on coal also are deductible, and in 1973 varied from 8.2 cents a ton (Knife River Coal Company) to 41.4 cents a ton (Decker Coal Company).[6]

Much of Montana's strip-mined coal is being sold to parent companies by a subsidiary division. The law currently allows profits of the subsidiary to be included among deductible mining costs for the parent company. This has the effect of reducing local tax collections.

The unpredictable size of tax collections under the Net Proceeds Tax also affects county budgeting officers. The proceeds vary widely among operating mining companies.

Western Energy (owned by Montana Power Company), reported a drop in net proceeds per ton from 82 cents to 38 cents in the last five years. Knife River Coal Company reported a drop from 91 to 53 cents in net proceeds during the same period.[7] Peabody's 1973 net proceeds calculation was 9.7 cents a ton; Decker's was $1.64.

In a general sense, the practice of connecting property taxes and corporate earnings is inherently inequitable because individual area taxpayers will see their mill levies rise in unprofitable years. A dry year with high land reclamation costs, for example, a coal company would get a tax break. Surrounding farmers and ranchers, though would suffer the opposite. Silver Bow County levies responded to the same sort of pressure in 1962, 1963, 1967, 1968, and 1971 - years when Anaconda Company had deficit earnings.[8]

Energy resource taxes also may be analyzed in terms of the gross value of the resource or its heating value. Table II does this.

TABLE II* --ENERGY RESOURCES AND TAXES (1973)

	Production	BTUs (trillions)	Gross Value	Taxes Paid[5]	Tax expressed as percentage of Gross Value[5]	Tax per Million BTUs (cents)[5]
OIL (barrels)	34,558,132	200,400[1]	$127,795,151	$12,434,812	9.7	6.2
COAL (tons)	10,721,423	192,800[2]	$30,218,462	$3.660,584	12.1	1.9
GAS (million cubic feet)	57,704	61,200[3]	$12,117,840[4]	$404,493	3.3	.66

*Source: Analysis of Fossil Fuel Taxation, Appendix I-IV, Leg. Council, July, 1974

1. 5.8 Million BTUs per barrel.
2. 17.98 million BTUs per ton.
3. 1.06 Million BTUs per 1000 cubic feet.
4. Average wellhead price of 21 cents per 1000 cubic feet.
5. Excluding corporation license tax and local property and equipment taxes.

Certainly one of the most important issues in the tax system is whether the state and local communities are receiving adequate taxes, in both quantity and timing of the tax receipts, to compensate the people for the loss of their finite resources and the disruption of their environment and society by impacts of energy development.

A serious problem is that local communities are burdened with service demands from increasing populations say, by construction activity, earlier than property taxes increase to compensate. Assessments become out-of-date and distorted, too. The Net Proceeds Tax will generate revenue only after mining has begun and even then the receipts cannot be predicted accurately. In the case of electrical generating facilities such as those at Colstrip, the problems are compounded because of the local dependance on property and equipment taxes and a heavy initial population influx.

Bill Gillin of Colstrip summed up the Rosebud County tax situation in his testimony at the Federal Coal Leasing Hearings in Billings, Aug. 14, 1974. Here are excerpts:

> The Colstrip schools had adequate facilities to absorb the impact caused by the reopening of the mines in 1968 but the influx of people since the beginning of the mine-mouth generating facilities (here) has been so great as to overwhelm the Colstrip schools. Last year it was even necessary to hold classes in the shower rooms and such important classes as Physics and foreign languages had to be dropped . . .
>
> My daughter, a fourth grader in the 1973-'74 school year . . . had a total of eight teachers due to splitting classes, moving from building to building and other factors brought on by the turmoil resulting from the great influx of students. Experiences such as this certainly aren't conductive to good education and is not fair to either the students such as my daughter or to the children of the mining families or the construction workers . . .
>
> The irony of all this is that the ranchers of the Colstrip district have not only seen their school, one of the best in Montana, rapidly deteriorate but have seen their tax burden expand with alarming rapidity. The

general fund budget of the Colstrip schools, high school and elementary, has gone from $399,413.00 in 1973-74 to $1,045,870.91 for the 1974-75 school year. The total mill levy for the Colstrip district has increased from 114.2 mills in 1972 to 134.641 mills in 1973 and will be 162.295 for 1974 and if the state mill levy had remained the same as last year, our mill levy would be over 177 mills. The actual increase amounts to over 42 per cent in just 2 years. We have been assured and reassured that once all this development is done all our tax worries will be over, but each year they become more serious. One of Montana Power's officials assured us that by 1978 we will be able to build a gold plated school. By that time my youngest daughter will be through the eighth grade and if her experiences continue as they were last year it will take much more than a gold plated school to compensate for what she has lost in the turmoil.

The promises of Montana Power's officials concerning the taxable valuation is becoming ever harder to believe when compared with the tax records of Rosebud County. Last year the increase valuation of cattle in Rosebud County set by the Department of Revenue actually exceeded the increase taxable valuation of all the coal development in the Colstrip area. This year the Department of Revenue increased the valuation of cattle 30 per cent and it nearly again exceeded the increase taxable valuation of all the coal development in the Colstrip area. Other increases in taxable valuation in the county far exceeded that of the Colstrip development. The total increase in taxable valuation in Rosebud County increased from $20,181,496 in 1973 to $26,650,000 for 1974. Of this taxable valuation increase of $6,468,504.00 the Colstrip development contributed only $1,688,545 or a total of 26 per cent. These figures are incredible when one considers that these developments are the largest industrial investments in Montana, two plants are under construction and one is to be producing in 1975. The investment in these two plants is suppose to exceed $180 million yet they have only added $1,688,545 to Rosebud County's tax base this year.

The impact they have caused is devastating to schools, roads, law enforcement, and recreational facilities in our county. For an example on roads, Montana 315 between Colstrip and Interstate 94 carried an average load of 50 vehicles and the State Highway Department projected a total of 2,500 vehicles a day by this summer and I'm sure it has reached or exceeded it by now. We have had a nearly four-fold increase in the law enforcement budget in Rosebud County in two years, the recreational facilities are inadequate for such increased population, Mr. Lippert, our area sanitarian, has warned of serious health hazards because of the proliferation of trailer courts and inadequate sewage, facilities. The City of Forsyth is facing very serious problems in both sewage disposal and water systems. Both Forsyth and Rosebud are experiencing rapid increases in school enrollment.

Under the present laws in the state of Montana small rural communities such as Colstrip was prior to the recent coal development are going to be destroyed by the impact of coal development. Present laws make it possible for the coal development companies to shift the tax burdens of their impact on the farmers and ranchers in the area being developed. Not only will these older residents be forced to accept a deterioration of roads, schools, law enforcement, recreational facilities, environment and life style but they will be subjected to unbearable tax loads to provide social services for the employees of the coal developers. This is exactly what has happened in the Colstrip area and if the hard lessons to be learned there are not heeded, every small rural community where this type of development occur will suffer the same fate . . .

Taxes on Montana energy resources should achieve these goals:

1. Tax as equitably as is feasible for gross value and energy value.

2. Simplify tax administration.

3. Create a more stable and predictable tax flow.

4. Introduce flexibility to help local jurisdictions, where fuels are extracted.

5. Encourage recovery efficiency.

6. Internalize social and environmental costs associated with energy development.

New Tax Structures

An alternative tax system for energy resources should first be simple and administratively streamlined. Proposed taxes should be equitable among the fossil fuels as far as conservation goals, extraction efficiency and social and environmental externalities are similar between the three fuels. This, however, is not the case. Neither market value nor energy content is a complete measure; market and energy values are not directly interchangeable.

One proposal might be to combine all the separate taxes into one or two taxes, perhaps retaining the Corporate License Tax and Property and Vehicle Taxes in their present form. The taxes would be payable annually or semi-annually.

The most equitable solution might be to levy a tax on both the BTU content and the gross value of the fuel at the well or mine. Table III shows how this system would have affected Montana's 1973 fossil fuel tax receipts given the proposed BTU and gross value tax rates.

TABLE III
Affect of Proposed Energy Taxes on 1973 Revenue

A. Tax Per Million BTU's

	1973 Production in BTU's (Trillions)	X	Tax	=	1973 Revenue
Oil	200,400		1.3¢	=	$2,605,200.
Coal	192,800		1.3¢	=	$2,506,400.
Gas	61,200		1.3¢	=	$795,600.

B. Tax Per $1.00 of Gross Value

	1973 Production in Gross Value	X	Tax	=	1973 Revenue
Oil	$127,795,151.		8¢	=	$10,223,612.
Coal	$30,218,462.		9¢	=	$2,719,662.
Gas	$12,117,840.		7¢	=	$848,249.

C.

	1973 Revenue (Actual)	1973 Revenue (Proposed)		Difference
Oil	$12,434,812.	$12,825,812.	+	$394,000.
Coal	$3,660,584.	$5,226,062.	+	$1,565,478.
Gas	$404,493.	$1,643,849.	+	$1,239,356.

The tax levy on BTU production among the three fuels is equal as BTU content is inherent in the fuel in its natural state. The levy as a percentage of gross value fluctuates slightly among the three due to the differences in recovery efficiencies and the social and environmental impacts resulting from the extraction phase. That fuel, coal, with the lowest recovery efficiency and greatest amount of detrimental externalities is taxed the heaviest in order to provide more revenues available for mitigating the externalities and encourage the usage of more efficient recovery techniques.

The Resource Indemnity Trust Tax of one-half per cent of the gross value could be included in the gross value tax and still be earmarked.

There will be a loss of the local share of the Net Proceeds tax under this proposal. There must be a portion of the state energy tax receipts returned to the counties and school districts in which development is taking place, perhaps a flat per cent of either tax or of the total, or proportions of various levels of receipts. The legislature could adjust this payment to match the needs of counties and schools.

Alternative solutions would be to allow counties and school districts to estimate future property tax valuations up to three years in advance and require prepaid corporate taxes. Receipts for these advance tax payments could be turned over in lieu of cash as taxes come due. Or, a special "impact tax" could be levied against industrial developments, based upon their projected capital investment or employment. These types of taxes would have to be authorized by the state.

At minimum coal companies should not be allowed to qualify for Class 7 property tax status and a three-year tax break on new industrial property.